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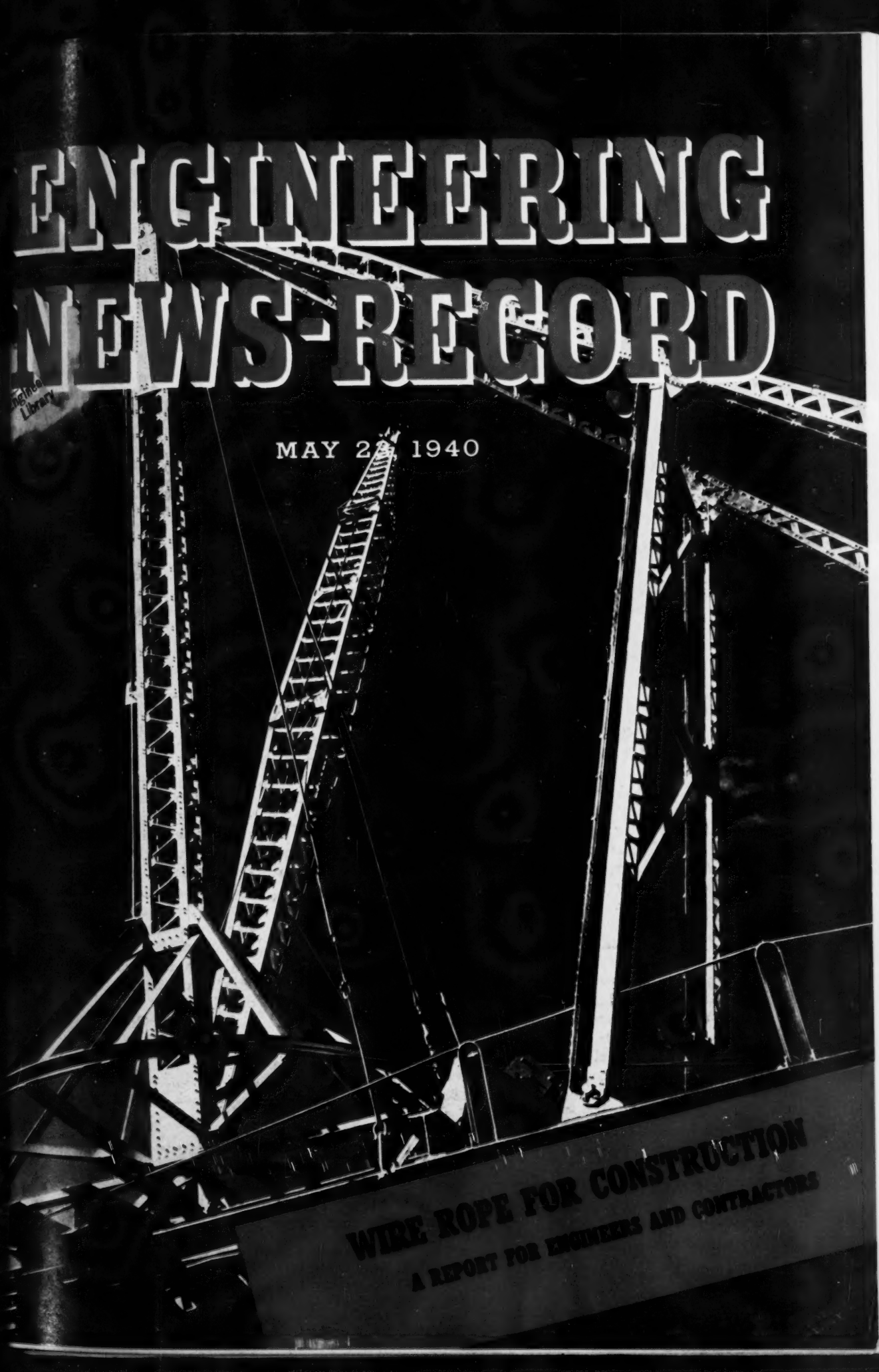

IN WELL CASING TOO, CORROSION COSTS YOU MORE THAN WROUGHT IRON

This recently completed well at the Kennett, Missouri, Waterworks, is one of the thousands throughout the country, protected with wrought iron. Byers 10-inch Wrought Iron casing was specified by Russell & Axon, Engineers, St. Louis, Missouri. The installation was made by Carloss Well Supply Company, Memphis, Tennessee.

The use of corrosion resistant well casing is considered imperative by authorities, because infiltration may render the water unfit for drinking, or for industrial process use. The extensive use of wrought iron is based on its proven ability to withstand both attack by water and by corrosive soils.

One large meatpacker cased a new well with wrought iron in 1914. In 1924 the length of flow line was increased with three lengths of another material. In 1935 this extension failed. Inspection showed the 21-year old wrought iron was still in excellent condition.

At Rockford, Illinois, a well cased with wrought iron served continuously for 52 years. When the casing was pulled so that the well could be enlarged, the casing was found to be still in very good condition.

A hotel in a seacoast town gets its water from an 800-foot well. Salt and brackish water permeates the soil to a depth of 350 feet. The wrought iron casing had served for 36 years at last report, with no trouble of any kind.

Through the cooperation of users, we have accumulated a large number of case histories of well casings exposed to a wide variety of water and soil conditions. If you have a well in prospect, and would like to choose the casing on the sound basis of actual experience, just give us the details. Our Engineering Service Department will furnish you comparative service data on wells where similar conditions were encountered. There is no cost or obligation.

A. M. Byers Co., Pittsburgh, Pa. Established 1864. Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston, Seattle, San Francisco.

BYERS GENUINE WROUGHT IRON

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Publication Office: 99-129 North Broadway, Albany, N. Y. • Editorial and Executive Offices: 330 West 42nd Street, New York

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Number copies of this issue printed: 35,146

THIS WEEK

● Ten miles of main dams and 30 miles of earth dikes give a quick picture of the large amount of work involved in the Santee-Cooper power and navigation project in South Carolina. The project will produce 173,000 hp of power initially and will open up the Santee River to navigation after a lapse of nearly a century.

● Safer night driving has been an object of auto and highway research for many years. The problem has been attacked principally in its relation to automobile headlights and highway lighting, but the New Jersey highway department has now pioneered work in light-reflecting curbs, which should help prevent many accidents.

● As a potential obstacle to Mr. Hitler's *blitzkrieg*, the Albert Canal was prominent in the news of the world only a few days back. The peacetime story of its construction and of its possible value in Belgium's defense is told on page 65.

● An eight-page section of this issue is presented as a concise handbook on the use of wire rope in construction. Result of a survey which included a 7,000-mile field trip, visits to wire rope plants and construction jobs, and discussions with a majority of the authorities in the field, its purpose is to serve the everyday needs of the wire rope user.

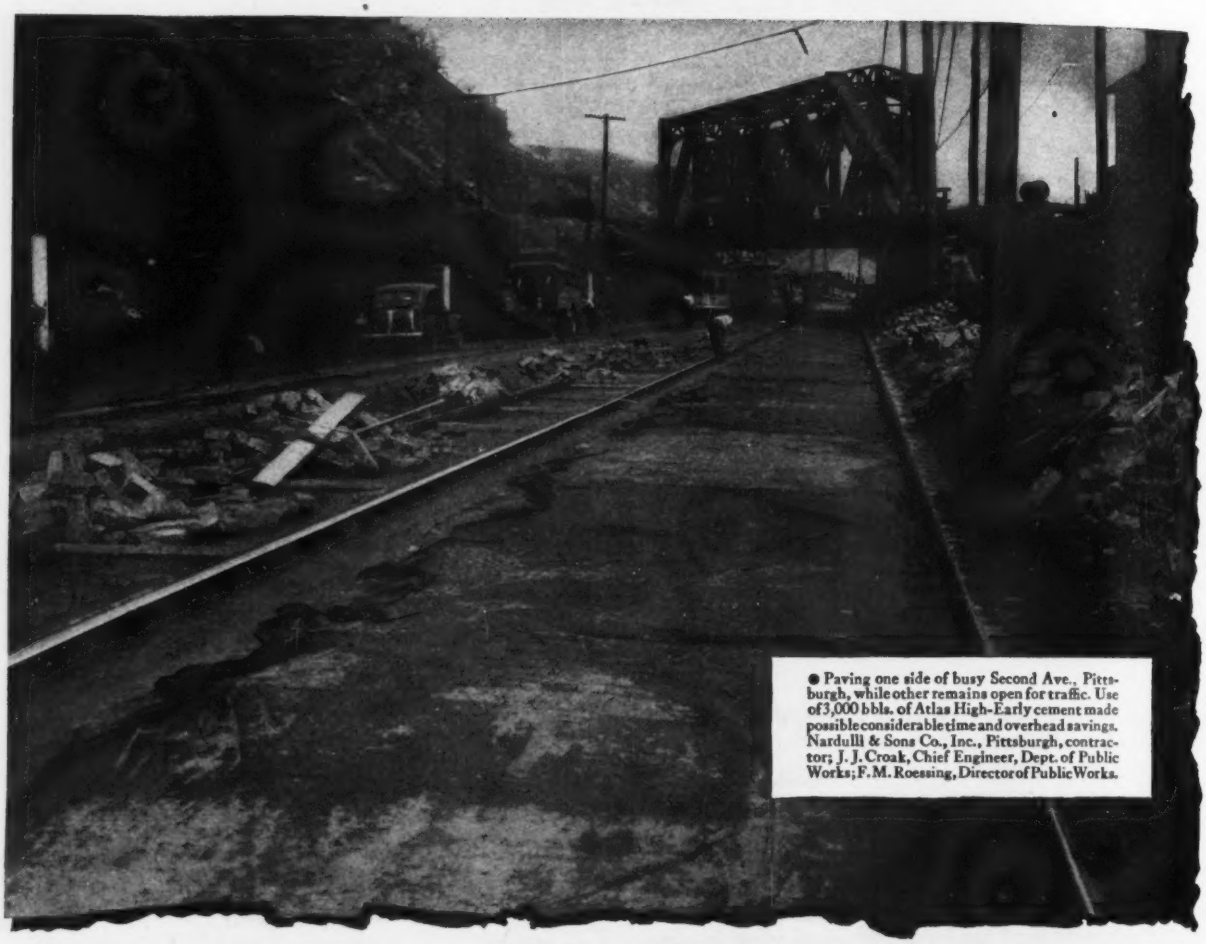
THINGS TO COME

OVER A QUARTER CENTURY AGO, Los Angeles completed its great 240-mile aqueduct from Owens Valley. During all these years, J. E. Phillips, has been in close contact with the aqueduct's maintenance and operation. An interview with him, to be published in the next issue, brings to light an invaluable store of experience which should be instructive to many water supply men.

RETRACTABLE divisional curbs have been installed in an 8-lane Chicago express road. How these increase the thoroughfare's capacity and efficiency will be told in an early issue.

Engineering News-Record's
ANNUAL CONSTRUCTION COST BOOK
will be incorporated in the June 20 issue.

REWARDED FOR SPEEDING on a busy road!



● Paving one side of busy Second Ave., Pittsburgh, while other remains open for traffic. Use of 3,000 bbls. of Atlas High-Early cement made possible considerable time and overhead savings. Nardulli & Sons Co., Inc., Pittsburgh, contractor; J. J. Croak, Chief Engineer, Dept. of Public Works; F. M. Roessing, Director of Public Works.

THE extremely heavy automobile and street-car traffic on Pittsburgh's Second Avenue forced complete repaving. Problem was to get this job done in the shortest possible time, with the least possible traffic tie-up.

The contractor knew he could make a large saving in repaving time by getting rid of long protection and curing delays. So he used a cement that gains strength rapidly—Atlas High-Early cement! First the base for one side of the road was concreted. Then—within a minimum amount of time—the contractor switched traffic and started concreting the other side.

The rewards? Each strip of road was ready for traffic much earlier than would otherwise have been possible. The job was done in winter weather, and so several days' protection and curing time was saved. Added up, these items made a substantial time and overhead saving!

Speed up your road, bridge and other construction by using Atlas High-Early cement. Although this cement costs slightly more, the savings in time and overhead often more than pay for the extra cost. For more facts, write Universal Atlas Cement Co. (United States Steel Corp. Subsidiary), Chrysler Building, New York City.

NR.-H-15

ATLAS HIGH-EARLY CEMENT

A UNIVERSAL ATLAS PRODUCT

ENGINEERING NEWS-RECORD

NEWS

Volume 124 MAY 23, 1940 Number 21

Imperial Valley Quake Ranks Fifth in Severity

Major damage to Alamo Canal in Mexico, and wrecking of structures in several California towns may entail a $5,000,000 loss

Not since the Long Beach shake of 1933 has the country experienced such a severe earth shock as visited the Imperial Valley in Southern California and Northern Mexico—the land of the All-American Canal—on the night of May 18. From reports by *News-Record's* Los Angeles correspondent, who visited the area the next day, from F. P. Ulrich, chief of the U.S.G.S. seismological field survey in California, and from the U. S. Bureau of Reclamation, it is possible to piece together a story of the damage, which may reach a total of $5,000,000 or more. Only in Long Beach in 1933, in San Francisco in 1906, in Santa Barbara in 1925 and in Charleston in 1886 was greater loss suffered, and the latter two were in the neighborhood of only $6,000,000.

Principal points of damage were on the Alamo or International Canal in Mexico, which roughly parallels the All-American Canal in the United States, and in the towns of Brawley, Imperial, Calexico, Holtville and El Centro. A severe water shortage is threatened by the canal breaks. Elevated steel tanks of earthquake-resistant design in Brawley and El Centro withstood the shock but those of non-resistant design in Imperial and Holtville collapsed. Utility pipes were not severely damaged although Brawley was without gas service for two days. The only fires reported were in Mexicali, across the border from Calexico.

According to F. P. Ulrich, preliminary calculations place the epicenter of the quake in the region just west of El Centro, on the most westerly of the three branches of the San Andreas fault that traverse the valley. The faults underlie a deep bed of sedimentary material, and considerable interest attaches to the effect which this rather unusual geologic formation had on the destructiveness of the earthquake; Japanese experience indicates that weak structures suffer most since strong structures, which can react as a whole, are cushioned by the sedimentary layer.

Ulrich reports that the breaks on the Mexican side of the International Canal are as much as a half mile wide over a distance of 35 miles, indicating danger of a serious water shortage. At Imperial (pop. 2000) half the buildings are totally destroyed, Ulrich states, and 80 per cent have been damaged. At Brawley (pop. 10,000) also about half the buildings have been destroyed, and

(*Continued on page* 35)

Those 50,000 Airplanes

American aviation manufacturers this week made known that they were well prepared to undertake the task of increasing the annual production to 50,000 war planes a year, as mentioned last week by President Roosevelt, but that a large expansion of factory facilities would be necessary. According to John H. Jouett, of the Aeronautical Chamber of Commerce, "the program outlined in the President's message today would seem to involve slightly more than a threefold increase in the number of employees with the plants working on a full shift basis, at the same time tripling the floor space of the airplane manufacturing plants and doubling the floor space of the engine plants."

The last available figures for floor space of airplane plants, as of July, 1939, put airplane factory space at 7,025,000 sq.ft. and floor space devoted to engine manufacturing at 1,975,000 sq.ft. Orders from the Allies have caused considerable expansion of both airplane and engine factory space since these figures were tabulated.

Wide World Photo

Half of the buildings in the town of Imperial were wrecked by the earthquake.

Tennessee Tax Valuations Upheld by Supreme Court

The system by which Tennessee sets values on the property of public utilities for tax purposes was upheld by the U. S. Supreme Court on May 20 in a suit brought by the Nashville, Chattanooga & St. Louis Ry. against the State Board of Equalization of Tennessee (No. 789, October term 1939). The case centered around the state's *ad valorem* tax under which values on private property are set by local tax bodies while the value of utility property is determined by the Railroad and Public Utilities Commission.

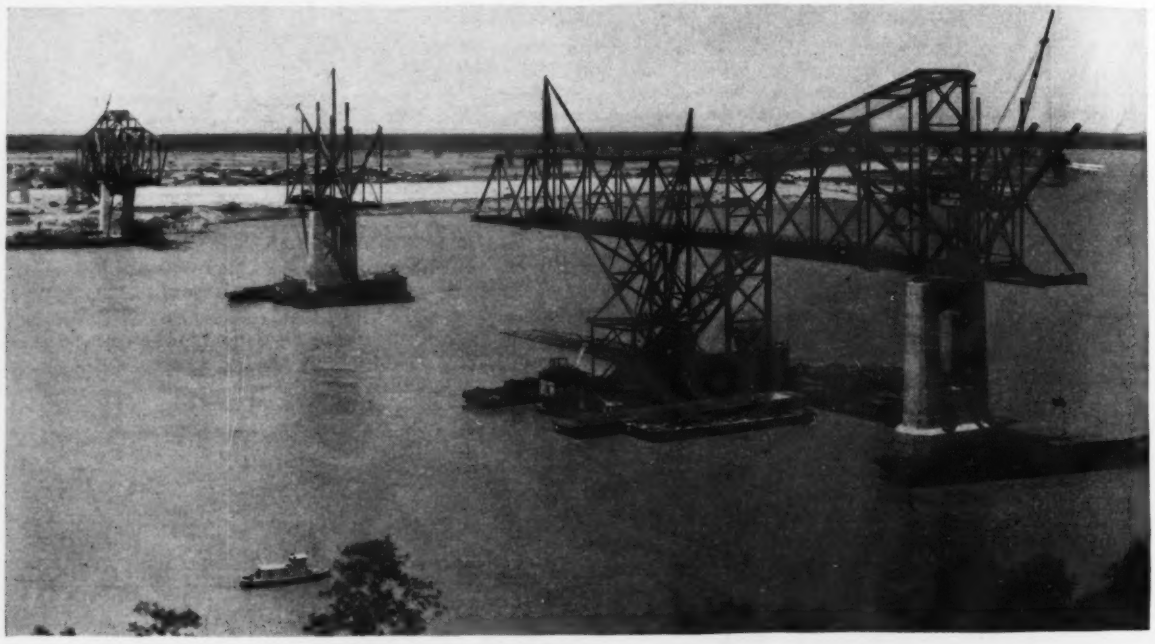
At issue were the acknowledged facts that this system results in a much higher value for public utility property than for other property and the question of whether the commission in determining "actual cash value" of the railroad's property within the state could continue to use the value of the previous biennium in the face of adverse economic factors that were held to reduce the property's worth. On the latter point, the court held that "railroads, unlike farms and city lots and stocks and bonds are not subjects of exchange," hence a "full cash value" is in many respects artificial and if a state needs higher taxes, the maintenance of a high value is not barred by the fourteenth amendment to the Constitution.

In ruling on the matter of placing higher value on utility property than on other property, the court held that so long as all utilities are treated alike the method is not subject to successful attack.

Chicago Tries to Break Union Ban on Transit Mix

Threats by union labor have always kept transit-mixed and ready-mixed concrete out of Chicago and the surrounding area. However, Assistant Attorney General Thurman Arnold's current investigation of why Chicago is the only major city in the nation where such concrete is not used, and a growing rebellion against the reign of Mike Carrozzo, boss of street construction workers, prompted city officials to call for bids May 17 on ready-mixed concrete for street paving. Bids were received on 3,990 cu. yd. for three jobs: (1) Laramie Ave., Harrison to Lake St.; (2) Homan Ave., Grand Ave. to Division St.; (3) Indianapolis Blvd., Ewin Ave. to city limits.

Two firms submitted widespread bids.



SIX TRAVELERS MAKE BLITZKRIEG ON NATCHEZ BRIDGE

ALTHOUGH involving only 8,220 tons of steel the new Mississippi River bridge being built by the city of Natchez, Miss., is being attacked by steel erection forces on three fronts simultaneously. Speed in beating the river to the "draw" if high water should threaten in the narrow and swift running channel make such an erection offensive necessary.

As shown in the above scene of operations a stiffleg derrick is moving west and a guy derrick moving east from the pier on the far (west) bank; guy derricks are moving both ways from the center pier; and in the foreground a stiffleg is moving east and a guy derrick west, these travelers having started from a fan type of falsework bent several panels west of the pier. By such balanced erection falsework is reduced to a minimum, a further concession to flood danger. The stifflegs are mounted on low movable towers and the guy derricks on rail trucks. Steel for these operations comes in by barge.

The Natchez Bridge is of continuous cantilever type having 5 spans of 560, 875, 875, 798 and 560 ft., from east to west, with a suspended section of 437 ft. in the first 875 ft. span. Length of structure is 4,205 ft., with approach roads bringing the total length of project to 8,136 ft. The 24 ft. roadway leaves the bridge on a curve in Natchez to join Canal St., which now is being widened.

Of the $3,450,000 cost of the bridge, $2,058,000 is an RFC loan and the balance is to be supplied by a PWA grant.

Designing and supervising engineers are Ash-Howard-Needles & Tammen, New York, for whom I. P. Hanson is resident engineer. The deep river piers were put down by the Dravo Corp. Bethlehem Steel Co., for whom David S. Gendell, Jr., is general manager of erection and A. F. McLane, resident engineer, has the steel fabrication and erection contract.

All work on the bridge is scheduled to be completed by September.

Their prices per cu. yd., and time of haul from plant to each of the jobs were: Material Service Corp., (1) $5.84, 22 min., (2) $5.84, 24 min., (3) $5.54, 9 min. Construction Aggregates Co., (1) $7.45, 15 min., (2) $7.60, 25 min., (3) $7.60, 15 min. The bids were taken under advisement by Oscar E. Hewitt, Commissioner of Public Works.

One of the union threats was that a mixer engineer would be required to ride each truck in addition to the truck driver. No one would comment on the possibility of this threat being carried out if the bids were accepted.

• • •

President Vetoes Harbor Authorization Bill

Because he believes the War Department should devote its energies to "military preparedness," rather than non-military activities, President Roosevelt, May 21, vetoed the $109,985,000 Rivers and Harbors Bill which would have authorized 151 projects and required surveys of 149 other projects. The President emphasized that there is now $133,000,000 authorizations outstanding.

No Cut in WPA Jobs

Bill before House would make $975,650,000 available during first eight months of fiscal year 1940–1941

A relief bill was reported to the House last week incorporating the President's suggestion that the $975,650,000 appropriated be made available during the first eight months of the fiscal year 1940-41. There is little doubt that advantage will be taken of this option, and if this is the case the bill will provide a rate of expenditure equal to that prevailing during the present fiscal year—employing an average of 2,000,000 relief workers.

Limits $50,000 to a Project

The proposed bill would limit the federal contribution to any WPA-built structure—building, bridge, tunnel, etc. —to $50,000. Under present law the limit is set at $52,000 and applies only to buildings. The new bill would exempt from the restrictions projects which had been approved by the President or on which the local contribution had been put up by means of a bond issue election or act of a state legislature prior to May 15, 1940.

This restriction is the only major change in WPA rules incorporated in the bill. In testimony before the House appropriations committee, WPA Administrator Harrington urged that the cost limit be dropped and also urged elimination of the requirement that project sponsors put up 25 per cent of the cost; this latter was retained in the bill as reported.

In general, however, the fact that many additional restrictions on WPA were not included is regarded as a victory for the administration. Representative Woodrum, who is given credit for most of the restrictive clauses in the 1939-40 appropriation, is opposing the new bill on the floor of the House. Rep. Woodrum proposes that half the WPA money be earmarked for a public works program performed by the contract method.

Woodrum's proposal was severely criticized by the President at a press conference last week. He asserted that a public works program would not employ as many people who are now on relief as would the same amount spent on WPA. Moreover, he said, earmarking of WPA money for specific projects would turn the bill into a pork barrel with every congressman trying to get money for his district.

The President charged that the Associated General Contractors is selfish in seeking to substitute contract work for WPA.

• • •

Yale Offers Fellowships In Traffic Engineering

The Bureau for Street Traffic Research at Yale University has announced the availability, beginning September 26, of 19 graduate fellowships, each of about $1,400. The fellowships, made possible through a grant from the Automotive Safety Foundation and from Alfred P. Sloan, Jr., will be offered in two groups. Seven will be available to employees of state highway departments, and the remaining 12 are to be available to employees of organizations having authority over and responsibility for the engineering phases of traffic control and to those considering a career in street traffic engineering.

Applications should be obtained from and returned to Maxwell Halsey, Room 311, Strathcona Hall, New Haven, Conn., by June 10.

British Combine Photo

BRITISH ARMY BUILDS PORTABLE HUT OF SAWDUST AND CEMENT

REMINISCENT of the steel Nissen huts of the first World War is this army hut being set up for test purposes in the old Horticultural Hall at Westminster, England. The sections, which are identical except at the crown, are cast of mineralized sawdust bound together with cement. They are assembled with drawing pins. The huts measure 62x19 ft. and can be set up or taken down quickly. The material of which they are made can be worked much like lumber.

Similar, although smaller, huts of corrugated steel were used extensively by American engineer regiments serving with the British Army in 1917 and 1918 in the Somme Valley around Peronne and Cambrai, places that again are in the headlines.

Dean Named to Bureau Of Contract Information

W. D. Dean has been appointed manager of the Bureau of Contract Information, succeeding Samuel M. Williams, who organized the Bureau in 1929 and continued as manager until his resignation last December. Dean took office on May 15, with headquarters in Washington.

Born in Chicago in 1892, W. D. Dean has long been active in construction. He served with Bates & Rogers on construction in British Columbia, and with Smith, Hauser & Locher on a section of the New York Barge Canal. In 1916 he was with the Portland Cement Association on concrete pavement problems. During the war he served in the army abroad, rising to the rank of Major of Engineers. Later he was on highway construction with J. O. Heyworth and the O'Rourke Engineering Co., and then went into surety bonding as agent and finally vice-president of the Southern Surety Co. and the Home Indemnity Co. Since 1932 he has been in business as contracting engineer in Richmond, chiefly on highway bridge work.

It is expected that the objectives and policies of the Bureau of Contract Information will be continued without change. The Bureau, originally organized by the Associated General Contractors and companies forming the Surety Association of America, is maintained jointly by surety organizations and contractors as an agency to check the responsibility of contract bidders, to furnish performance records.

VIADUCT SHORTCUTS TRAFFIC CONGESTION ON NEW ORLEANS STREETS

CONSTRUCTION of a viaduct at New Orleans to carry the Airline Highway over the New Basin navigation canal, shown running across the page in the top photograph, and Ponchartrain Boulevard, which parallels the canal, will not only avoid traffic congestion on this boulevard and on Carrolton Ave., running vertically at the left, but will also eliminate two railroad crossings for highway traffic. Motorists now using the Airline Highway which parallels the Louisiana & Arkansas R. R., upon reaching Ponchartrain Boulevard must travel along this street until reaching Carrolton Ave., and then along this avenue to Tulane Ave., which leads to the commercial district. This requires crossing the L. & A. tracks twice and a surface level bridge spanning the navigation canal.

The overall length of the new structure is 1,442 ft. and it carries a 60-ft. roadway flanked by two 5-ft. sidewalks. Span lengths vary from 48 to 82 ft., the longest allowing a 24-ft. slipping clearance. Although the east and west approaches are of usual construction, consisting of 30-ft. tower spans alternating with 44-ft. intermediate spans, skewed spans are required over a spur track of the L. & A. R. R. and the canal. For this construction the steel girders transverse to the roadway were somewhat longer than the girders parallel to the roadway. For that reason expansion rockers, as shown in the lower photograph, are set for expansion transverse to the roadway.

The Kelleher Construction Co., Dallas, Tex., is the general contractor. N. E. Lant is bridge engineer and G. F. Stevenson is resident engineer for the Louisiana State Highway Commission, the owner.

Wide World Photo

What remains of the 50,000-gal. elevated water tank at Imperial whose design is said not to have incorporated earthquake-resistant provisions.

California Earthquake

(*Continued from p.* 31)

nearly all buildings in the business district are damaged. Although newer residential structures were only slightly hurt, older residences suffered severely and many will be condemned. At Holtville although a 50,000-gal. municipal water tank collapsed completely, other damage was restricted to a few walls in the business district and to some residential chimneys. Damage at El Centro and Calexico was moderate (which casts some doubt on the preliminary location of the epicenter). Ulrich observed fences which had slipped 12 ft. along the fault with a difference of elevation of 3 ft.; it is pointed out that this may represent a mere surface slippage, however, rather than movement of the underlying strata.

Residents who went through the 1933 Long Beach earthquake report that the present shock was more severe. Intensity is now estimated at 10 on the modified Mercali scale. The Survey is well equipped to study the shock, having strong-motion seismographs at El Centro, San Diego and Pasadena.

Bureau of Reclamation field men report that damage to the All-American Canal is comparatively slight. The New River siphon (a pipeline bridge), considered the chief danger point, came through without damage. The Alamo River crossing suffered a break in the Dorman drain outlet but was otherwise undamaged. All the power drops except Drop No. 5 are unscathed. At No. 5 some offsets were observed at the joints and some spalling of the bell joints. There was some backfill settlement at all structures except the New River siphon. The new Briar Crossing moved slightly at each end but there was no leakage. Two bents of the Ash Canal temporary flume crossing were wrecked by sloughing of the bank. The fault line crosses the canal at a point about 60 miles from its head near Calexico. At the Ule No. 3 turnout nearby, the outlet transition structure moved north 8 ft. There was considerable bank sloughing over a 15-mi. stretch near the fault between Drop No. 5 and the Alamitos flume.

All towns in the Valley are on restricted water supply, since, in addition to the break in the Mexican canal, the East high line canal of the All-American system was broken near Holtsville. Bureau of Reclamation engineers believe both canals can be repaired within a week or ten days. However, preliminary investigations by the WPA and the RFC's Disaster Loan Corp. appear to indicate that it may be several months before water can be restored.

There is no present intention of bringing in water through the All-American Canal. In its present stage of completion only the areas now served by the East high line canal would be benefited by such a move, and major damage might be done by a precepitate introduction of water into the unfinished portions. Final opening of the canal is scheduled for this fall, and the canal has not yet been seasoned. In any case, it would take at least ten days to bring water through the canal, so if the damage in Mexico can be repaired within that time the question will not arise.

The major structures of the Yuma project—Laguna Dam, Yuma Canal, and the siphons—are undamaged. Ten small flumes were destroyed, and earth upheavals may have interfered with some lateral irrigation ditches.

Chicago Stages Building Week

"Now is the time to build" is theme of program sponsored by Chicago Building Congress

In a determined effort to impress upon the public that now is the time to build homes, apartments, in fact, all classes of buildings, the Chicago Building Congress sponsored Building Industry Week in Chicagoland May 13-18. Through proclamation of the week by Mayor E. J. Kelly of Chicago and mayors of surrounding towns, through local radio broadcasts and through thousands of pamphlets distributed by real estate interests, building and material supply houses, contractors and subcontractors, and the building trades unions, the current low costs of land and building construction were emphasized. The campaign also stressed easy financing methods, high values of building investments today and the general business stimulation provided by building construction.

The high spot of the week was a luncheon meeting held by the Chicago Building Congress, attended by 500 persons interested in building work. I. N. Tate, vice-president of the U. S. Chamber of Commerce, and the Weyerhaeuser Sales Corp., and Cress E. Stedman, vice-president of Certain-teed Products Corp., were the principal speakers. Both pointed out the values now obtainable in modern construction and both declared present investments in houses and buildings would increase through the inflation that is bound to come. Tate favors pushing of medium-priced homes as a relief of the current housing shortage. He stated that providing suitable housing for the middle-class income group would release enough older housing to accommodate the low-income class. Stedman, however, held that standardized low-cost home construction was the solution of the housing problem.

• • •

Board Named to Accredit Architectural Schools

A national board for accrediting the schools of architecture in the United States has been organized by the American Institute of Architects, the Association of Collegiate Schools of Architecture and the National Council of Architectural Registration Boards. Edwin Bergstrom, of Los Angeles, head of the American Institute of Architects, has been chosen as the initial president of the new group, which will be known as the National Architectural Accrediting Board.

Watts Named President Of James Stewart & Co.

At its annual meeting on May 8 James Stewart & Co., one of the country's largest building contracting firms, elected Harry D. Watts president to succeed James C. Stewart who was made chairman of the board, a position that has been vacant since the death of Alexander M. Stewart last December. Watts has previously been executive vice president. At the same meeting Roger Peabody, vice president, was elected to the board of directors to fill the vacancy created by A. M. Stewart's death.

• • •

TVA Project Designated Fort Loudoun Dam

Fort Loudoun Dam has been designated by the Tennessee Valley Authority as the name of the $25,000,000 project heretofore known as Coulter Shoals. The title Coulter Shoals, derived from a section of the Tennessee River selected as a possible site in preliminary surveys, is no longer applicable for the present location, which is some 45 miles below Knoxville on the Tennessee River. Fort Loudoun, said to be the oldest structure of historical significance built in Tennessee by English speaking people, was located in the vicinity of the present dam site.

Active work on the dam, a concrete structure similar to other TVA dams on the Tennessee, is scheduled to start soon. When completed, it will be about 135 ft. high with an overall length of 3,900 ft. to create a reservoir 50 miles in length. With completion of the project, a 9 ft. navigation channel from the Ohio River to Knoxville will be provided.

• • •

Bonnet Carre Spillway Maintained with Goats

Substantial savings in maintenance costs of the Bonnet Carre Spillway, which provides for discharge of excessive flood waters from the Mississippi River into Lake Ponchartrain at New Orleans, are anticipated by the Army Engineers this year in purchasing 6,300 goats to graze on the greater part of the 3,150-acre spillway area. The goats cost $15,350.

Two years ago, $400,000 was expended in a WPA project to clear the center strip of the spillway of all underbrush of less than 5 in. in diameter. Last year the center strip was maintained at a cost of about $7 per acre.

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Large Drydock Project Urged for New York City

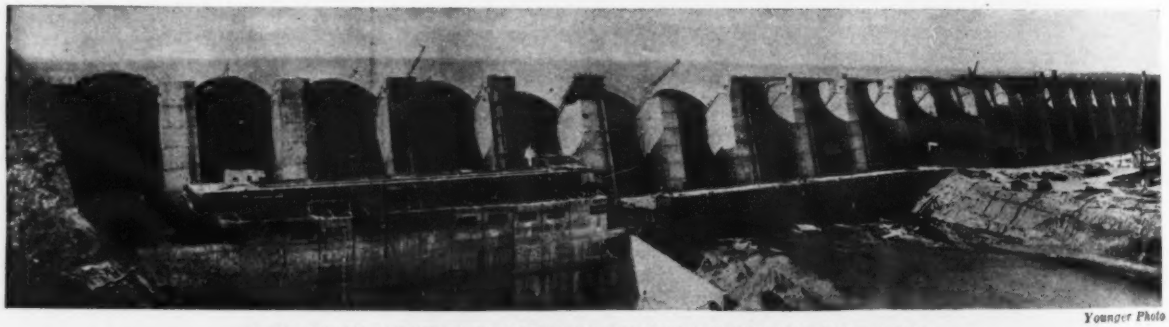
Construction at New York City of a drydock of sufficient size to accommodate the largest naval and mercantile ships has been recommended in a report to the U. S. Navy Department by the Port of New York Authority. The drydock, 1100 ft. long and capable of extension to 1200 ft., is estimated to cost $11,600,000 to $17,800,000. It has been suggested that the work, which is among the projects navy officials may recommend to Congress for early action, be financed by a $7,000,000 federal grant and by the sale of Port Authority bonds.

WASHINGTON HIGHLIGHTS

Special reports by Paul Wooton

FHA'S RENTAL HOUSING DIVISION has lowered still farther the maximum rentals which it will permit on newly insured apartment projects and in so doing may well have put a halt to its activities. Henceforth, no projects will be accepted for insurance contemplating rentals above $13.50 per room, except in metropolitan areas of over a million population where $15 will be permitted. The new rules also include a flat prohibition of elevator apartments.

A year ago rental limits were set at $15 and $16.50, and the result was an almost complete cessation of FHA activity in this field since builders seem uninterested in building low-rental apartments. That the present change should be introduced in the face of this experience indicates how seriously FHA takes its theory that the only safe rental investment is low-rent property. Most of the FHA-insured projects which are in difficulty are in the upper rent levels.



Younger Photo

THE PROJECT THE GOVERNOR OF OKLAHOMA CANNOT STOP

PENSACOLA DAM, being built on Grand River in northeastern Oklahoma by the Grand River Dam Authority as a hydroelectric project with a $20,000,000 PWA loan and grant, is the project Gov. Phillips of Oklahoma has tried without success to halt. In March he had the National Guard ordered out to stop the work, claiming that the state of Oklahoma should receive $800,000 as pay for certain highways that would be flooded. However, a temporary restraining order shortly afterward allowed construction to continue. Late in April the federal government was granted a permanent injunction preventing interference with the work. Gov. Phillips is now appealing the case to the U. S. Supreme Court.

Monday of this week water at the dam stood at El. 698, with 380,000 acre-feet having been stored since March 21, when gates of the dam were closed, to form a 14,000-acre lake. Water is rising behind the dam at the rate of a foot a day.

Massman Construction Co., Kansas City, represented by R. G. Stowell as construction superintendent, is general contractor for the work. Holway & Neuffer, Tulsa, Okla., are the consulting engineers for the Grand River project. They are represented at Pensacola Dam by Victor H. Cochrane, design engineer, and Lee Hendrix, chief construction engineer. The Public Works Administration is represented on the site by Floyd Conway, Lester M. Marx being PWA project engineer.

OBITUARY

COL. WM. GOFF CAPLES, 61, for the past three years area engineer for the 9th Corps Area, U. S. Engineers, died May 15 in San Francisco. Following his graduation from West Point in 1901, Col. Caples did two years duty in the Philippines. In 1914 he was placed in charge of the 4th Mississippi River District at New Orleans. During the World War he commanded the 310th Engineers in France and was division engineer of the 85th Division.

GEORGE SIMPSON, 71, who retired in 1933 after 29 years as chief engineer for the Thompson-Starrett Co., builders of New York City, died in that city May 18. Simpson, born in Aberdeen, Scotland, on coming to the United States soon joined the Keystone Bridge Co., Pittsburgh, Pa. Later he worked with the Metropolitan West Side Elevated Railroad, Chicago, Ill., with the Dutton Pneumatic Lock & Engineering Co., New York, and the Jackson Architectural Iron Works, New York. He joined the Thompson-Starrett Co. in 1901, being made chief engineer in 1904.

COL. PHILIPPE BUNAU-VARILLA, 80, who at the age of 26 acted as director-general of the French company that tried unsuccessfully to construct the Panama Canal, died in Paris May 18. Col. Bunau-Varilla is credited with helping to organize the revolution which resulted in the separation of Panama from Colombia. Later he was appointed Panama envoy to negotiate the treaty, which turned the Canal Zone over to the United States Government. Returning to France following dedication of the canal, he served in the World War as a major with the French engineers.

MAJ. GEN. HAROLD H. MATTHEWS, adjutant general of the Canadian military forces, died in Ottawa, Ont. May 12. From 1933 to 1938 Col. Matthews was commandant of the Royal Military College of Canada, the engineering training college for the Dominion military engineers which has produced many of Canada's civil engineers.

JOHN J. MCCAUGHEY, 87, retired general contractor, died in Chicago May 15. McCaughey did grading and landscaping work for the Chicago World's Fair of 1893 and for the Chicago park system, as well as various grading projects for the Chicago, Burlington & Quincy R.R.

NORMAN A. MACKENZIE, 50, civil engineer and for the past three years a member of the engineering staff of the Canadian Department of Public Works at St. John, N. B., died recently in that city. Mackenzie served with the Royal Engineers during the World War, being promoted to lieutenant. Returning to Canada in 1919, he was a member of the engineering department of the Bell Telephone Co., Toronto, for three years.

WILLIAM L. COOLING, 72, civil engineer formerly connected with the Baltimore highway engineering department, died in that city May 13. For a time Cooling also worked with the Maryland State Roads Commission.

CHARLES V. REYNOLDS, 49, formerly president of the New England Road Builders Association and a member of the state emergency public works commission of Massachusetts since 1933, died at Canton, Mass., May 13. Reynolds, a graduate of the Massachusetts Institute of Technology in 1912, served as engineer for three years with the Boston Transit Commission before entering the contracting business with offices at Canton.

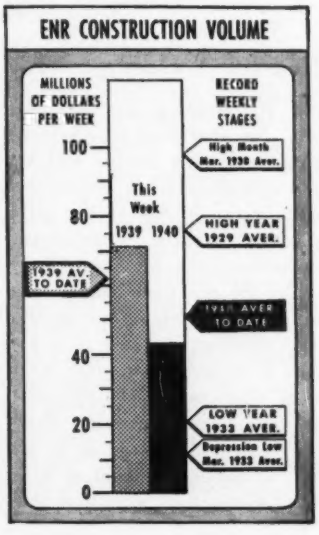
CONTRACTS AND CAPITAL

ENGINEERING construction awards for the week total $43,857,000, a decrease of 6 per cent from last week, and 39 per cent below the volume for the corresponding 1939 week.

Public construction tops the preceding week by 11 per cent, but falls 42 per cent below the high volume of a year ago. Private awards for the week are 27 per cent lower than a week ago, and 30 per cent lower than a year ago, the first time in the last eight weeks that they have fallen below their respective 1939 values.

The 1940 construction volume, $1,058,278,000, is 18 per cent under the volume reported for the initial 21-week period last year. Private awards for the period top a year ago by 13 per cent, but the public cumulative total is 29 per cent lower.

In the classified construction groups, waterworks, sewerage, commercial building and large-scale private housing, and streets and roads exceed their respective totals of a week ago; and waterworks, industrial buildings, and earthwork and drainage top their 1939-week values.



New capital for construction purposes for the week totals $96,919,000, an increase of 368 per cent over the volume for the corresponding week last year. The current week's new financing is made up of $60,865,000 in short-term municipal notes for USHA construction, $35,380,000 in state and municipal bonds, $500,000 in corporate security issues, and $174,000 in RFC loans for public improvements.

New construction financing for the year to date, $575,644,000, is 31 per cent below the volume for the initial 21-week period last year.

CONTRACTS

(Thousands of dollars)

	Week Ending May 25 1939	May 16 1940	May 23 1940
Federal	$5,556	$4,072	$5,179
State & Municipal	44,147	21,914	23,587
Total public	$49,703	$25,986	$28,766
Total private	21,619	20,754	15,091
TOTALS	$71,322	$46,749	$43,857
Cumulative 1940	(21 weeks)		$1,058,278
1939	(21 weeks)		$1,294,829

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial building, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1939 21 Wks.	1940 21 Wks.
NON-FEDERAL	$523,127	$575,644
Corp. Securities	118,062	74,644
State & Mun.	278,318	416,884
R.E.A. loans	37,801	.....
U.S.H.A. loans	88,712	78,430
R.F.C. loans	234	5,686
FEDERAL	$311,427	$.....
TOTAL CAPITAL	$834,554	$575,644

FHA MORTGAGES

	Week Ending May 20 1939	May 11 1940	May 18 1940
Selected for appraisal	$25,814	$29,545	$29,703*
Cumulative 1940	(20 weeks)		$473,702*
1939	(20 weeks)		$464,954

* Subject for revision.

ENR INDEX NUMBERS

Index Base = 100		1913	1926
Construction Cost	May '40	238.86	114.82
Building Cost	May '40	201.17	108.75
Volume	Apr. '40	191	84

COMMENT AND DISCUSSION

Readers' opinions on matters that concern engineers and contractors

Coney Island Boardwalk

Sir: In reference to the article on the moving of the Coney Island boardwalk (*ENR*, May 2, 1940, p. 616) I wish you would make the following correction: The Griffin Wellpoint Corp. furnished only the wellpoints and pumps necessary to supply the water to the jetting equipment. The jetting equipment and the truss for handling the deck stringers were fabricated by R. Steel & Sons, Long Island City, from plans furnished by E. W. Foley, Incorporated.

E. W. FOLEY
President, E. W. Foley, Inc.
Brooklyn, N. Y.

Vertical Curves

Sir: The recent discussions of vertical curves as applied to highways and railroads in *Engineering News-Record* give complicated methods of solution of a simple problem. It is necessary to remember only one simple formula based upon the law of the parabola. This law states that the elevation of any point on the curve varies as the square of its distance from the PC of the curve.

Expressed algebraically:

$$y = \left(\frac{x}{L}\right)^2 C$$ See illustration

Procedure of calculation:

1. Calculate elevations on tangent PC-A at points in question. 2. Calculate elevation at PT. 3. Calculate value of C. 4. Calculate values y from basic formula using distances x to points in question. 5. Add values of y to elevations calculated in step 1 of procedure to give required elevations on curve.

Example:

Given

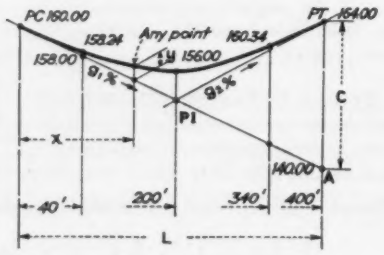
$L = 400'$
$g_1 = -5\%$
$g_2 = +7\%$
$x = 40', 200', 340', 400'$
Elev. at PI = 150.00

Required

Elevations on parabolic curve at points 40′, 200′, 340′ and 400′ from PC.

Procedure of calculation:

1. Elevations on tangent PC-A:



At PC $150.00+\frac{400}{2}\times.05=160.00$

At $x=40'$ $160.00-40\times.05=158.00$
At $x=200'$ $160.00-200\times.05=150.00$
At $x=340'$ $160.00-340\times.05=143.00$
At $x=400'$ $160.00-400\times.05=140.00$

2. Elev. at PT $150.00+200\times.07=164.00$

3. Value of $C=164.00-140.00=24'$

4. Values of y

$$y_1=\left(\frac{40}{400}\right)^2 24=0.24$$
$$y_2=\left(\frac{200}{400}\right)^2 24=6.00$$
$$y_3=\left(\frac{340}{400}\right)^2 24=17.34$$
$$y_4=\left(\frac{400}{400}\right)^2 24=24.00$$

5. Elevations on curve.

At $x=40'$ $158.00+0.24=158.24$
At $x=200'$ $150.00+6.00=156.00$
At $x=340'$ $143.00+17.34=160.34$
At $x=400'$ $140.00+24.00=164.00$

The above method is simple, easy to remember, and does not require reference to cumbersome formulas.

THOMAS L. KENNEDY
Lt. (j.g.) CEC—USNR.
Pensacola, Fla.

A Plea for Welding

Sir: Arc welding has too many doctors. An operation which is perfectly natural, very simple and very easily accomplished has largely been changed in the minds of the public to an art which takes on the mystery of voodooism with an admixture of the art of the medicine man.

The public is beginning to think that the welding operator is a cross between a miracle man and a professional magician. This opinion is groundless. The only thing that a welding operator can do is to hold the end of an electrode at a certain distance above the deposited metal and advance it along the seam to be welded at a certain speed. There is nothing more that is involved in this operation. It is neither complicated nor difficult. As a matter of fact, with proper electrode, proper setting of the welding machine and proper preparation of the work, it is practically impossible to make a weld which will not stand up in service without having it so evident to the inspector that he would immediately reject it. It is possible to have defects in the steel that cannot be seen which will make a steel structure dangerous. It is impossible, however, to make a weld on that structure which is dangerous without its being obvious to anyone looking at the weld.

The reason we hear so much about the necessity of skill and care in welding is largely due to the fact that the operation itself is so simple that it is difficult to find much about it to discuss in papers, lectures and statements. Therefore, many of these eccentricities which are volubly discussed in magazine articles, lectures and statements, consist of theoretical possibilities which exist only in the minds of the lecturers and seldom exist in reality.

It is time that we got away from trying to make this very simple operation mysterious. It is time that we recognize the fact that the metal deposited by the shielded arc electrode is definitely better than the parent metal it is joining. It is time we recognize that there has never been a failure on an insured pressure vessel made by the shielded arc process. It is time we recognize that in the usual design if only half a weld is made it will withstand all of the normal requirements of the structure. It is time we recognize that failures in welds which are made by the methods recommended by any reliable manufacturer never exist. It is time we recognize that there is no mystery in welding and that making a welded joint is far more simple than making a riveted joint and more simple than making the steel which is joined together by this process. It is time we recognize that to spend time, money and attention in removing the least possible flaw from the deposited metal is silly in the light of the obvious flaws which must occur in the parent metal.

A factor of safety is used to guard against these flaws in the steel.

That is more than is needed in any commercial weld.

When we do recognize these facts we will have done two things: first, we will have given the green light to one of the most economical processes now known for the production of many structures; second, we will have removed one of the fears which the uninitiated have developed regarding a perfectly normal manufacturing operation.

J. F. LINCOLN
President, Lincoln Electric Co., Cleveland, Ohio

Unusual Design Problems

Sir: Your editorial on "Overcoming Difficulties" in the April 11 issue indicates the feelings of a designer after a piece of work, which is a departure from everyday design, is recognized as successful. Since I was the designer of the structure described on p. 447 of the March 28 issue, I am naturally encouraged to think that probably the designer is coming to be recognized for his contribution to progress.

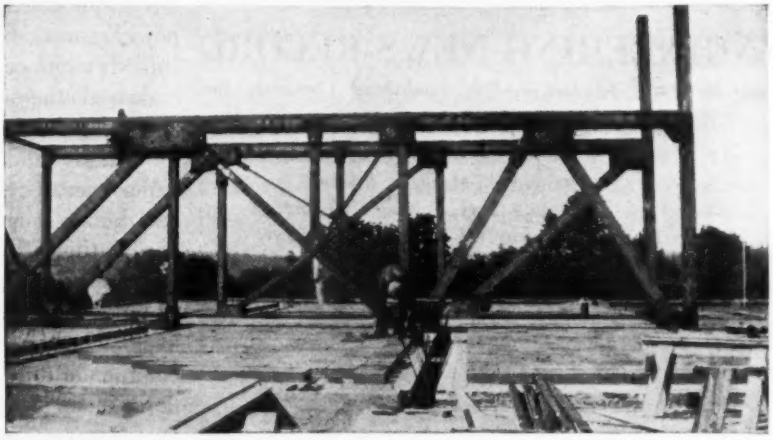
I would like to call your attention to a slight typographical error in the article of March 28. The last word of the 17th line should read "piers" instead of "pins."

HAROLD H. GILBERT
Senior Bridge Engineer
State of California Division of Highways

Welded Trusses

Sir: Standing on the sidelines today overhearing some critical observations about the temerity of an engineer who would design a welded truss as illustrated in *Engineering News-Record*, April 11, 1940, page 54, it occurred to me that perhaps it would help convince engineers that there is nothing so new or radical about heavy welded trusses if they could also see the enclosed photo of welded trusses we designed and constructed back in 1929 at the Loch Raven Training School for Boys.

Due to impossibility of hauling completed trusses to the site these trusses were assembled on a scaffold built under the bottom chord and then completely field welded in place. It is of interest to note that at the time we felt gusset plates to be necessary, though under today's advance in welding methods we would probably eliminate some of the gussets used. These two trusses carry heavy loads, supporting three floors and roof of an all-welded fireproof building; in addition there are twelve other long span welded trusses supporting roofs, all of which were field fabricated.



These welded trusses with slot-welded gussets were built in 1929.

This welded design saved about twenty per cent as against the same design riveted. Steel was furnished by Morris, Wheeler Co., Philadelphia and welding was done by the King Welding Co.

VAN RENSSELAER P. SAXE
Consulting Engineer
Baltimore, Md.

Labor Relations

Sir: We wish to question the following statement in an editorial in your April 25 issue: "The uncertainty also gave union organizers an opportunity to harass engineering firms whose organizations have not been receptive to their approach."

The reason that we question the above statement is due to the fact that in your issue of April 18 you reported the fact that the Federation of Architects, Engineers, Chemists & Technicians had filed charges with the Wage-Hour Administrator of the New York region in the cases of three companies employing draftsmen and engineers. This was based on the fact that these companies had failed to comply with the provisions of the Fair Labor Standards Act requiring overtime pay at a minimum rate of time and a half in the case of their draftsmen who were required to work overtime hours.

Are we to understand that the request made of the Wage-Hour Administrator to investigate the overtime situation in any particular company in order to see whether the provisions of the act are being complied with or not constitutes "harassing?" These charges were filed at the request of the draftsmen affected and after our officers verified the claims made. No one has charged that a failure to pay the legal overtime rate is a deliberate act on the part of these companies. Is it not our obligation to ask the administrator to investigate and see that such a situation is rectified? The companies were cited before the administrator at the specific request of the draftsmen employed by them. Do you object to having such matters handled through the organization of the draftsmen who are thereby exercising their legal rights to collective bargaining and to representation by the organization of their own choosing?

MARCEL SCHERER
International Vice President
Federation of Architects, Engineers, Chemists and Technicians

We did not intend to suggest that anyone be denied his rights; all we asked for was that the rights of employers as well as those of employees be respected. If, as Mr. Scherer claims, the FAECT is the duly chosen representative of the draftsmen of the concerns to which Mr. Scherer refers, any question such as a possible violation of the wage-hour act as it relates to those draftsmen could have been settled directly with the employers under the Wagner labor-relations act. Calling on the Wage-Hour Administration to make an investigation of the working conditions of *all* the employees of the companies in question, engineers as well as draftsmen, to our mind lacked the element of fair play.—EDITORS.

ENGINEERING NEWS-RECORD

Copyright 1940, by McGraw-Hill Publishing Company, Inc.

Volume 124, Number 21

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May 23, 1940

WIRE ROPE is too often regarded as merely shelf hardware. On construction work where lives and profits depend upon its proper selection and use such a casual attitude toward wire rope is never justified. Where it exists, knowledge of the fundamental facts relating to its design, manufacture and selection is usually lacking. A feature of this issue is a special report on wire rope planned to correct this lack of information and therefore to be of aid in all wire rope problems.

Out to Get Experience

WITHIN THE NEXT FEW WEEKS a large number of young men will start to make their way in the world as engineers. They will be well equipped with the theories on which engineering is based, will be full of enthusiasm and vigor but will lack one essential—experience. That they now seek to gain. In gaining experience they should remember the advice of a great military leader who said: "Experience should be a springboard under your feet, not a ball and chain at your ankles." The engineer who lets his reasoning be limited simply to methods and processes that experience has shown to be sound fails to live up to his full potentialities as an engineer. What makes a great engineer is ability so to organize the facts established by experience as to make them the starting point for further advance and new achievements.

Reflecting Curbs for Safety

APPLICATION of the fundamental principles of light reflection to curb construction by the New Jersey highway department has added new safety to night driving. On a rainy night when other road markings are obliterated, a gleam of light is reflected from the ordinary headlamp beam as it strikes the fins that project from the new curb face. One of the major cement companies has taken the lead in pointing out defects in its previously recommended smooth white curb practice and has enthusiastically endorsed the newer theory. Development of the curbs to their present high efficiency has required long study and three years of actual installation experience. Greater efficiencies and economies are still being sought, and attention is being given to application of the principles to the pavement itself and to other highway markers. Those who are willing to leave the marked paths for study and experiment are always to be praised, and special commendation is due the New Jersey highway department for this scientific approach to the problem of safer highways.

Fifty Thousand Airplanes

NO BETTER PHRASE could have been chosen to carry to the man in the street the idea of a great preparedness effort than the President's "at least 50,000 planes a year." Leaving aside the overlooked fact that it would take half a million men to service and fly such a fleet, and the debatable subject of whether our machine tool capacity could be enlarged rapidly enough, a look at what the construction industry could do in providing the necessary plants is revealing. Readers of this journal will remember the article in the June 22, 1939 issue "Airplane Factory Built in 11 Weeks." This addition to the Glenn Martin plant in Baltimore involved 440,000 sq. ft. It was in operation less than 3 months after the designers were told to go ahead with the plans. Aircraft leaders estimate that we would require 17,000,000 sq. ft. of additional plane and engine factory space to turn out 50,000 planes a year. That would require less than 40 construction jobs similar to that at the Glenn Martin plant. In terms of money they would represent about $30,000,000. An industry that has handled ten billions of work in a single year could take them in stride.

No Lesson Learned

ANOTHER WPA BILL is before Congress. Considering what we have learned about the cost of construction when carried out as unemployment relief it is no improvement over its predecessors. No attempt is made to taper off this type of spending. Modest proposals to shift some of the burden to the purses of local communities and to limit the size of heavy construction projects are meeting great opposition. So far as can be ascertained no thought was given to the fact that cities will not resume normal financing of con-

struction so long as federal gifts are dangled before their eyes. This is evident from the strong WPA support found among local politicians. New York's Mayor LaGuardia, whose great public works accomplishments have only been possible because of WPA, unwittingly made this plain last week when he attacked the A.G.C. for "lobbying" against WPA heavy construction, an attack that comes with poor grace from the head of that great WPA lobby, the U.S. Conference of Mayors. It was a prime case of the pot calling the kettle black, the only difference being that the pot is a much more potent power in Congress, and is either blind or selfish to the merits of the case. No unemployment relief is accomplished by transferring jobs from regular construction workers to unemployed workers outside the industry. The unemployment problem will not be solved so long as no lessons are learned from past experience.

Construction and War

EIGHT MONTHS AGO, when war was declared, there was wide belief that it would have an immediate effect on construction. Because large-scale destruction did not begin at once and because, for an as yet unexplained reason, the Allies did not think haste in building up supplies of materials such as planes was necessary, these effects have been experienced in only modest degree. Furthermore, it has taken the amazing German successes in Holland, Belgium and France to blast our complacence of eight months with regard to our own preparedness. What might have happened last September is beginning to happen now. And we as well as France and Britain are face to face with an emergency.

Events of the past week make plain that we are about to embark on a tremendous preparedness program and that our industrial machine may well be turned into a vast factory for the Allies. Over night we have ceased to be neutral and have become merely non-belligerent. The distinction is important. Being non-belligerent means that we accept a vital part in the war both to aid the Allies to win and at the same time to prepare ourselves for the consequences if they lose. It means that the construction industry, its engineers, contractors, and manufacturers, will become an integral and important part of this effort, and it means that great responsibilities are to be placed on individuals and organizations in that industry.

Compared with the planning that has gone into industrial organization, whereby 10,000 plants know what products they will be required to manufacture, and in what quantities, the construction industry has received little attention. Since its resources and production capacity were believed to be adequate for almost any degree of war effort this neglect of construction's problems by the war planners was perhaps natural. But the problems can hardly be ignored much longer by the industry itself.

What its problems will be depends upon a number of "ifs," which is not unusual since future planning must always contend with alternatives.

If we are merely going to spend a couple of billion dollars to build up our own supplies of guns, planes and munitions, there is ample construction management and manpower eagerly awaiting employment. But if we are going to add to our own preparedness efforts a great manufacturing program for the Allies, the problem begins to loom large. Then if we should repeal the cash-and-carry provision of the Neutrality Act and free our ships to travel the seven seas, we would have a tremendous shipbuilding program on our hands; with all available shipyard ways now occupied by merchant marine and navy ships, shipyard expansion would be inevitable.

What if this effort to make our Army, Navy and Air Corps of unchallengeable strength and to aid the Allies becomes so great that civil works are curtailed? What if governmental control of construction is imposed? What if bidding on government construction is superseded by negotiated contracts? What if WPA forces are turned to building powder and loading plants, shipyards and fortifications? What if factories that make construction equipment or materials are assigned to manufacturing what somebody thinks are more essential war materials? What if. . . . But the list of possibilities is too long. The important question is, has the construction industry through its technical societies, its trade associations, its individual thinking, done any planning to give the nation's leaders the benefit of its counsel?

Whether the least or the greatest of these possibilities becomes reality, planning is essential. Military authorities will require cooperation from civilian engineers and construction agencies as they did in the last war. Congress will need advice. It is not too soon for the industry to begin worrying about its war responsibilities. By the same token the time is ripe for detailed plans of operation and cooperation to be worked out, to the end that the construction industry knows as surely as does industry in general its role in the days to come.

FIG. 1. STRIPPING THE SITE OF THE SPILLWAY OF THE NEARLY EIGHT-MILE-LONG DAM ACROSS THE SANTEE RIVER BOTTOMS.

Developing the Santee and Cooper Rivers

***Contents in Brief**—A combined power and navigation project is being built in South Carolina by diverting the Santee River into a reservoir formed in the Cooper River watershed from which water can be dropped 70 ft. down into the Cooper River for power development. Included in the project are two long dams, chiefly of earth and sand fill, many miles of dikes, a power plant of 173,000-hp capacity and a navigation lock of 75-ft. maximum lift that will permit barge traffic from Charleston to go up the Santee and Congaree rivers to Columbia, S. C.*

THE SANTEE-COOPER PROJECT in South Carolina is primarily for power development but it includes a start toward redevelopment of barge navigation between Charleston on the seacoast and interior cities such as Columbia and Camden. Flood waters of the Santee River are to be stored in two large reservoirs for power purposes.

The present undertaking is being carried out by the South Carolina Public Service Authority, a state agency created in 1934. Its origin, however, goes back to incorporation of the Columbia Railway and Navigation Co. in 1913. Engineering studies were made around 1921 by the Foundation Company and in 1925 by Murray & Flood.

The present work is being financed by a PWA grant of $15,435,000 and loan of $18,865,000 secured by revenue bonds of the authority. In addition the WPA is expending $6,495,000 for land clearing in the reservoir areas, thus bringing the total costs to $40,795,000.

Fig. 2. Brick lock of the old Santee Canal at Black Oak Church. Built nearly 150 years ago, much of the brickwork still is sound. The lock chamber is only 10 ft. wide.

The Santee is one of the large rivers of the Atlantic Seaboard, having a drainage area of 14,700 sq. m. and a runoff that ranges from a low of about 3,000 cfs to a recorded peak of 368,000 cfs. It is a silt-laden stream with no natural harbor at its mouth. To the south lies the Cooper River, largely a tidal estuary with only a small drainage basin. Charleston lies along the fine natural harbor formed by that estuary. Only a low divide separates the Santee River valley from tidewater which extends inland along the Cooper River 35 miles to a point where a 40-foot drop from the Santee River can be developed in about 25 miles. Nearly 150 years ago a private company took advantage of this narrow divide and built a 22-mile canal with 13 brick locks to create a canal from Charleston to the inland cities of the Santee basin. The projected new canal will follow part of that old route, the lower 15 miles serving also as the tail canal for the power plant.

The present plan, stated briefly, is to dam the Santee at a point where its low water surface is at about El.

40, raising the water level to El. 75, cut a 7.5-mile diversion channel through the divide, build a second dam and a series of dikes to close off the valley of a small tributary that comes into the Cooper River at a point close to tidewater thus forming a second reservoir from which water can be dropped 70 ft. through a power plant to a tail canal at tidewater in the Cooper River.

Santee Dam

The diversion dam on the Santee River is to be built across the flood plain of that stream where the average ground level is at about El. 42. It will raise the river to a maximum level at El. 75. The dam will be nearly 8 miles long and will consist of three sections, a hydraulic fill 4.3 miles long across the cypress swamp that makes up the greater part of the flood plain, a concrete spillway section 3,400 ft. long in the river bottom, and an earthfill 2.8 miles long extending from the spillway to high land on the south side of the river.

Details of Santee Dam are shown in Fig. 5.

For the long hydraulic fill the swamp is to be stripped of stumps, muck or plastic clay leaving the remainder of the sandy clay blanket in place to join to the clay core, thus forming a continuous clay cutoff of L shape, the vertical leg being the core of the dam and the horizontal leg being the upstream blanket running under the upstream half of the earth dam and upstream from the dam an indefinite distance. This will check seepage down into the underlying sand that extends to below sea level over most of the area. The dam is to be built of sand pumped by hydraulic dredge from a borrow-pit below the dam and roughly parallel to it. In the sluicing operations the fines will be washed to a central pool to form a core. Core pool drainage will be through pipes down through the core and extending out to the upstream side of the dam.

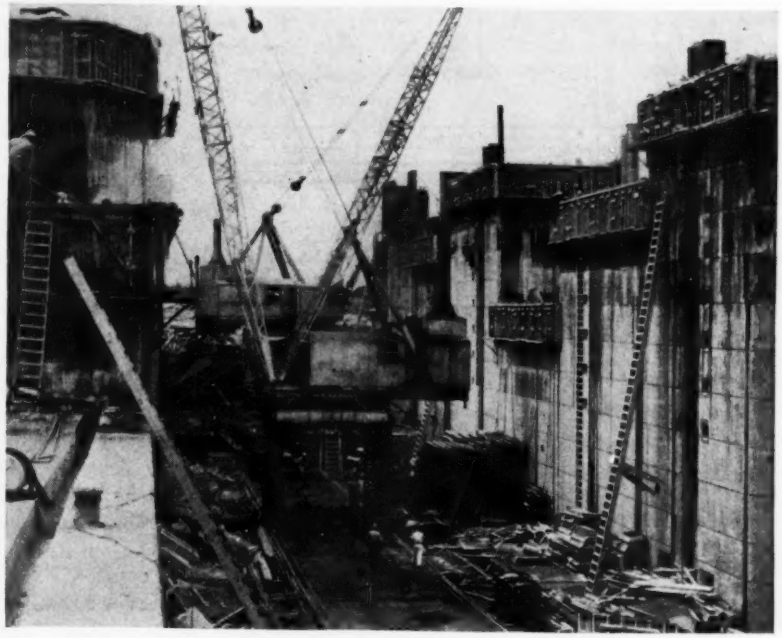


Fig. 4. The navigation lock will have the highest single lift of any lock in the world, 75 ft. Because of this high lift, floating mooring bits are to be installed in vertical recesses in the walls, one of which is shown at the right.

The contractor is required to exercise care in stripping to avoid any unnecessary stripping under the upstream half of the dam. Excess fines wasted from sluicing will be discharged upstream to reinforce the natural clay blanket.

The spillway is to be a hollow reinforced concrete structure surmounted by steel crest gate. It is to be built on a concrete slab laid directly on the sand bed that carries the hydraulic fill. As this sand bed has ample bearing value the design calls for stripping only to a depth to provide a uniform level across the spillway area. The foundation slab not only will be used to support the spillway but also to protect the downstream area against erosion. The apron slope of 1 on 4 is based on the Madden Dam design, which has proved successful in destroying energy under varying tailwater conditions. Final details of the design were worked out on the basis of model studies made in the Vicksburg hydraulic laboratory.

A steel sheetpile cutoff driven to impervious material under the upstream heel of the slab will check

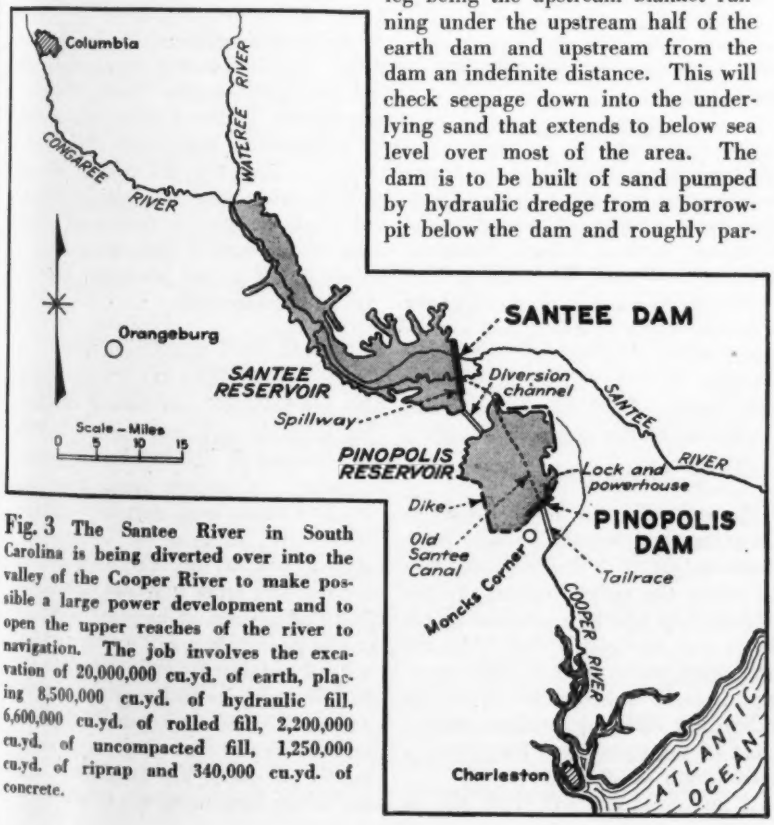


Fig. 3 The Santee River in South Carolina is being diverted over into the valley of the Cooper River to make possible a large power development and to open the upper reaches of the river to navigation. The job involves the excavation of 20,000,000 cu.yd. of earth, placing 8,500,000 cu.yd. of hydraulic fill, 6,600,000 cu.yd. of rolled fill, 2,200,000 cu.yd. of uncompacted fill, 1,250,000 cu.yd. of riprap and 340,000 cu.yd. of concrete.

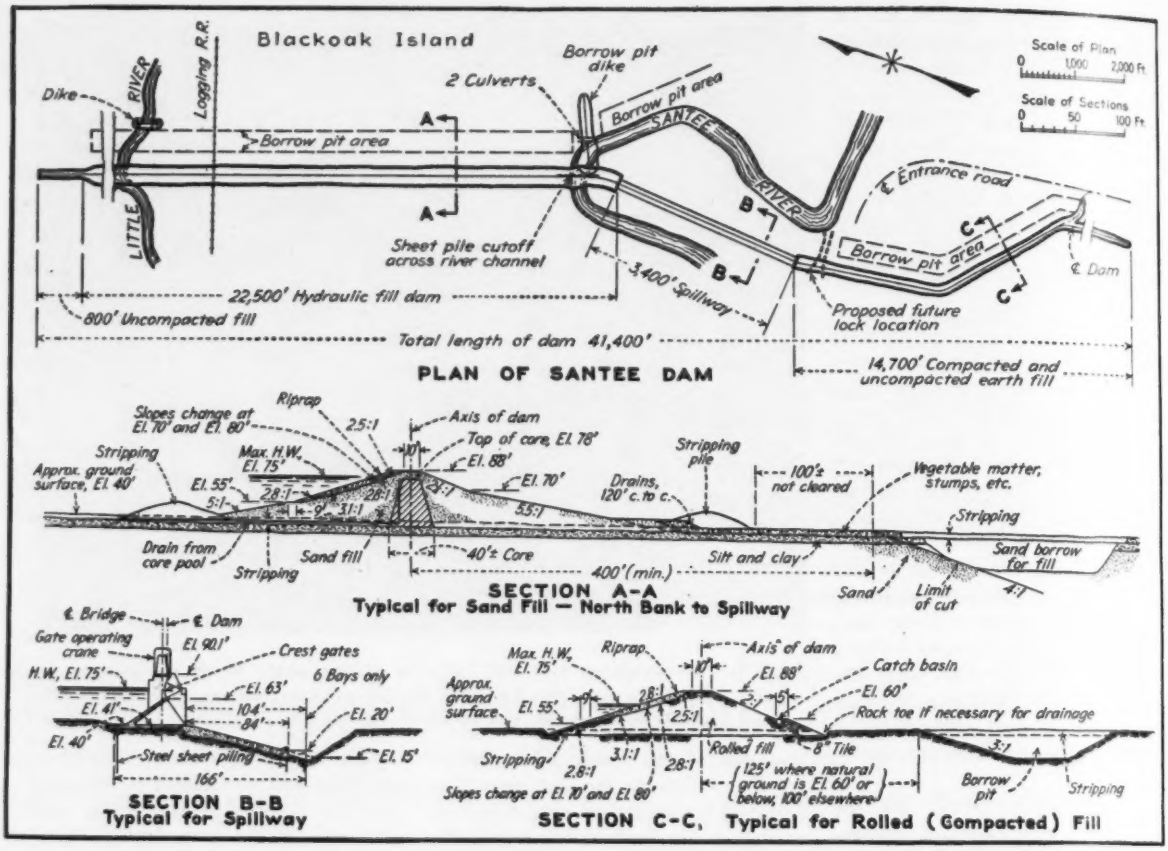


Fig. 5. Santee Dam is to be nearly 8 miles long, chiefly of earth and sand fill, but having a concrete spillway 3,400 ft. long.

underflow and the whole foundation slab and spillway apron will be protected against uplift by a layer of porous concrete with drains to points below the dam. As a further precaution, the natural clay blanket above the spillway is to be restored.

The spillway is to be surmounted by 62 Tainter-type crest gates each 50 feet long. This will give a spillway capacity of 500,000 cfs at El. 75 and 800,000 cfs at El. 80. The maximum flood of record is 368,000 cfs. A flow of 500 cfs must be maintained below the dam at all times. For regulating streamflow and for filling the downstream channel in advance of a flood flow, thus checking the erosion that would develop otherwise, six gates are to be gang-operated from a line shaft driven at very slow speed. When fully opened, these gates will create a bank-full stage, about 50,000 cfs. The other gates can be operated individually by traveling cranes as required.

The location of the spillway in a bend in the river, as shown in Fig. 5, is intended to simplify construction and diversion operations.

South of the spillway the dam consists of a long earthfill extending to high land.

Diversion canal

From the south side of the reservoir formed by Santee Dam a diversion canal is to be cut through to the reservoir formed behind Pinopolis Dam in the Cooper River valley. This canal will be 7.5 miles long, will have a bottom width of 200 ft. and a maximum depth of 28 ft. Its bottom will be at El. 49 to 45 to provide a navigable depth of 10 ft. at maximum drawdown of the reservoir, El. 60.

Pinopolis Dam

Pinopolis Dam is to be 2.1 miles long, largely an earthfill with a maximum height of 78 ft. for about 3,000 ft. across the valley bottom. In the high section will be a concrete power plant and navigation lock. As the maximum water level in this reservoir is to be at about the rim of the valley, low dikes are required around most of the reservoir. They have a total length of 30 miles.

A tail canal that will serve also as a navigation channel is being cut from the powerhouse for a distance of 4½ miles to the Cooper River. Deepening of the Cooper River for 9 miles below that point also is required. This channel will be about 300 ft. wide with a minimum depth of 11 ft. to give a maximum velocity of not over 3 mph when all six units in the power plant are operating at full capacity.

A large power plant

The power plant is to have space for five hydraulic turbines of 40,000-hp. capacity each and one of 13,300 hp., a total of 213,300 hp., ultimate capacity. Contracts have been let for four of the large units and for the small unit, bringing the initial capacity to 173,300 hp. Embedded parts for the fifth large unit also are to be installed as part of the curent work.

The power plant will operate under a head ranging from 75 down to 60 ft. All units are to be propeller type with anticipated maximum efficiencies on the Newport News units approaching 94 per cent. The small unit and two of the large ones are to have ad-

justable blades. These are being manufactured by Allis-Chalmers Mfg. Co. The other large units are to have fixed blades. Two complete units of this type and the embedded parts of the third are being built by the Newport News Shipbuilding and Drydock Co. Two large and one small electric generators are being built by Westinghouse and the other two large generators by General Electric.

An ample supply of water is available for power production. When operating under full load, the six units of the ultimate installation will require 32,000 cfs. This can be met by the normal flow of the river in average years for 10 per cent of the time. For the remainder of the period the deficiency will be met by drawing down the two reservoirs, which have a combined area of 250 sq. mi. and a usable capacity with a 15-ft. drawdown of 1,630,000 acre-ft. less evaporation.

Navigation redeveloped

In 1793 work was begun on a canal that followed much the same route as will be followed by the present diversion of the Santee River into the Cooper River valley. It was 22 miles long, 35 ft. wide at the water surface and 4 ft. deep and had thirteen locks of brick and stone with lock chambers 10 ft. wide. That canal was opened in 1800 and functioned until 1851 when it was abandoned due to railroad competition. However, some shallow draft navigation persisted on the Congaree and Wateree rivers, the two main branches of the Santee.

The navigation facilities of the Santee-Cooper project will provide a 10-ft. channel from Charleston up through the Santee reservoir. To reach Columbia, the nearest city of any size, will require the extension of the 10-ft. channel 30 miles up the Congaree River. That work is not included in the present undertaking.

The lock in Pinopolis Dam is notable in that it will have a maximum lift of 75 ft., the highest in this country. The lock chamber will have a width of 60 ft. and a clear length of 184 ft.

R. M. Cooper is general manager of the South Carolina Public Service Authority and F. R. Sweeny is chief engineer. The Harza Engineering Co., Chicago, L. F. Harza, president, is in charge of the engineering work. For the latter firm, F. A. Dale is engineering manager, H. G. Gerdes, hydro-electric engineer, C. H. James, hydraulic engineer, E. Maerker, structural engineer, F. A. Olmsted, electrical engineer, H. P. McKean, civil engineer, C. E. Wattles, chief construction engineer, W. R. Buie, resident engineer at Pinopolis Dam, C. L. Huff and H. P. Kay, resident engineers at Santee Dam, E. M. Fucik, soil technician and K. H. Talbot, concrete technician. For the PWA, Kenneth Markwell is PWA project engineer and J. H. Moore is principal assistant. E. B. Miller is principal mechanical engineer, S. P. Darlington, electrical engineer, and L. S. Harmer, principal civil engineer.

The principle contracts that have been let and the work still to be put under contract are given in the article that follows.

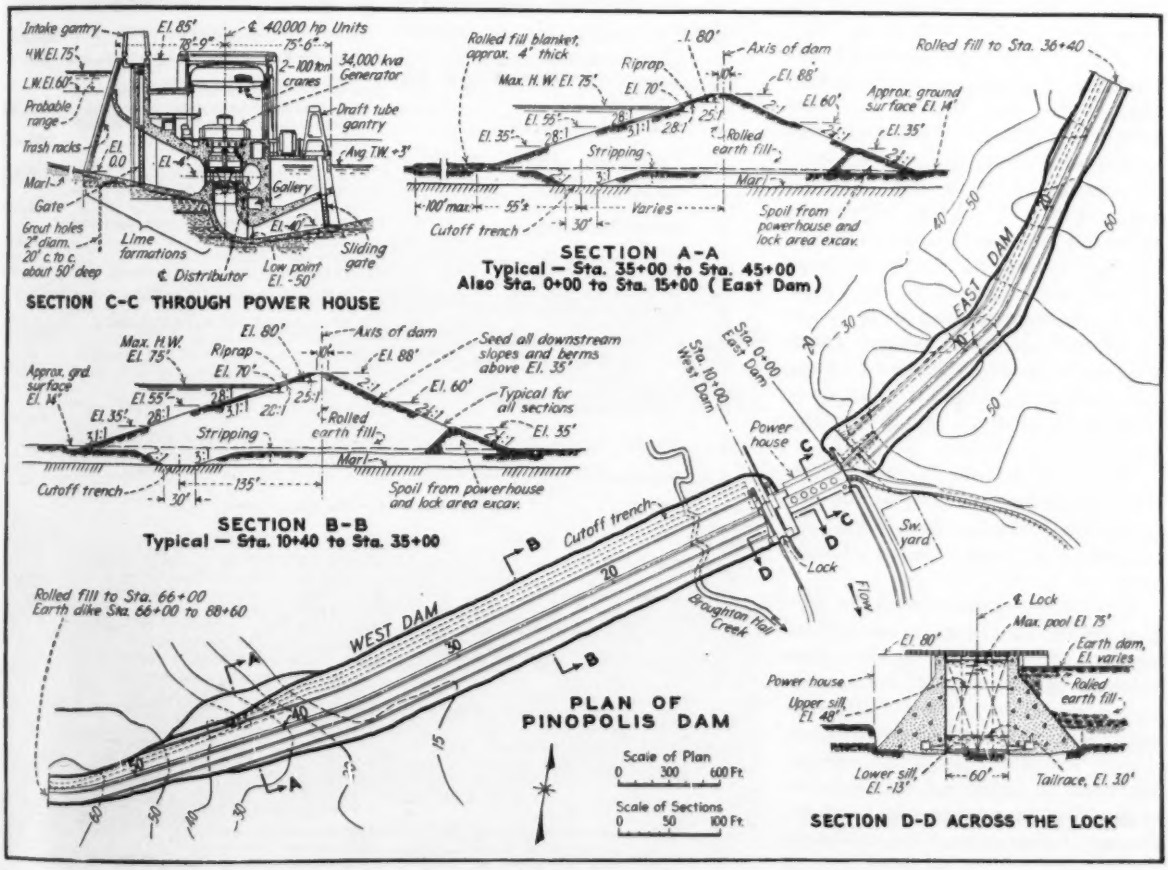

SECTION C-C THROUGH POWER HOUSE
SECTION A-A
Typical — Sta. 35+00 to Sta. 45+00
Also Sta. 0+00 to Sta. 15+00 (East Dam)
SECTION B-B
Typical — Sta. 10+40 to Sta. 35+00
PLAN OF PINOPOLIS DAM
Scale of Plan
Scale of Sections
SECTION D-D ACROSS THE LOCK
WEST DAM
EAST DAM
Cutoff trench
Spoil from powerhouse and lock area excav.
Rolled fill to Sta. 66+00
Earth dike Sta. 66+00 to 88+60
Rolled fill to Sta. 36+40
Broughton Hall Creek
Power house
Lock
Sw. yard

Fig. 6. **Pinopolis Dam consists of large earthfills flanking the concrete powerhouse and the navigation lock, which are built at the low point in the valley.**

Santee-Cooper Construction Operations

CONSTRUCTION is under way on all the major elements of the Santee-Cooper project except the tail canal. Work was begun first at Pinopolis Dam. There the rolled earth dike to the east of the powerhouse is completed except for the high end which will suround a short section of gravity concrete dam forming a connection with the powerhouse. Riprap and slope protection is yet to be placed.

The east dike was placed largely with shovels and dump trucks from a borrowpit within the reservoir area. The soil as it came from the face of the cut gave about the desired mixture of sand and clay, hence little soil selection was needed. On this job there was a slight excess of moisture hence harrowing was needed and rainy weather or even heavy showers were not welcomed by the contractor. Similar soil conditions exist on the earth dam at the other side of the valley. Work there was shut down during part of the winter on account of wet weather but has been resumed. There, where the quantities are much larger, earth is being handled in large carrying scrapers averaging 25 yd. to a load for the Tournapulls and 14 to 15 for the Euclids. Some bottom dump trucks are used. Sheepsfoot rollers are used, and unusually high compaction is obtained where the big tractors run.

Fill on these jobs is paid for on the basis of borrowpit measurements, hence the contractor has a financial interest in getting maximum compaction.

Proctor tests to determine the relation between moisture content, compaction and resulting density, were made in borrow material before construction started. These tests, supplemented and checked by frequent density samples from the fill, are being used to determine the moisture control limits for the required density. During construction, the moisture content of the fill is obtained prior to rolling by frequently weighing and drying (in about 45 minutes' time) small samples in portable field laboratories. These determinations are used by the inspector to determine the amount of rolling necessary.

Density samples of the compacted soil, obtained by pressing a cylinder of known volume into the fill, are taken and tested daily. At predetermined locations, larger "chunk" samples are taken and tested in the main field laboratory for shear strength, permeability, grain size and consolidation, as well as for density and moisture content.

Stripping of the undesirable surface materials under the high earth-fill that forms the west end of Pinopolis Dam has been completed and some fill has been placed. Grouting of a thin layer of sand that lies between the marl and limestone at about El. —8 was carried out during the late winter.

The powerhouse and navigation lock lie near the low point of the valley. They are founded on the soft limestone that lies below the marl. Concreting of the lock is well along, the deep excavation for the draft tubes has been completed and concrete is being placed in that part of the structure.

Concrete aggregates come from a variety of places. A coarse, sharp sand is obtained from up the Santee River and fine sand for blending is taken from the reservoir area. Small gravel, up to 2½ in., is obtained from

PRINCIPAL CONTRACTS FOR THE SANTEE-COOPER PROJECT

Contract Number	Contractor	Description	Amount
1	Sprague & Henwood	Preliminary Exploration	$65,000
2	Newport News Shipbuilding & Dry Dock Co.	Two 40,000-hp. fixed-blade turbines and embedded parts for a third	555,000
3	Allis-Chalmers Mfg. Co.	Two 40,000-hp. and one 13,300-hp. Kaplan turbines	935,000
4	Westinghouse Electric & Manufacturing Co.	Two 34,000-kva generators	764,000
5	General Electric Co.	Two 34,000-kva and one 11,350-kva generators	871,000
6	Central Engineering Co.	Pinopolis Lock (concrete), west dam and power plant substructure	4,272,000
7	W. C. Shepherd	Pinopolis east dam	143,000
8	W. C. Shepherd	Santee south dam and entrance road	173,000
9	Wilbanks & Pierce, Inc.	Santee north dam (hydraulic fill)	2,370,000
10	McCarthy Improvement Co.	Santee spillway dam (concrete)	3,090,000
11	Virginia Bridge Co.	Furnish and install 62 spillway gates	225,000
12	C. G. Fuller and J. B. Britton	East dike (Pinopolis) — section 1	485,000
13	J. A. Terteling & Sons	East dike (Pinopolis) — sections 2 and 3, north and west dikes and diversion canal	948,000
15	Cornell-Young Co.	St. Stephen-Wilson Landing R. R.	184,000
16	Virginia Bridge Co.	Furnish power plant and lock gates and steel	445,000
17	Lakeside Bridge & Steel Co.	Lock machinery, spillway cranes and power plant intake and draft tube gantry cranes	229,000
18	Manning, Maxwell & Moore, Inc.	Two 100-ton generator room cranes	50,000

Low Bids Received — Not Yet Awarded

Schedule Number	Low Bidder	Description	Amount
1	General Electric Co.	Four 25,500/34,000-kva and one 8,512/11/350-kva, 3-phase transformers	$269,000
2	General Electric Co.	Ten 115-kv, 600-amp., 1,500,000-kva., 35-cycle reclosing duty oil circuit breakers	170,000
3	Four Bidders	Two 1,000-kva, 13,200/480-volt 3-phase station service transformers	11,000
4	Allis-Chalmers Mfg. Co.	Four 115-kv, 600-amp., 1,500,000-kva, 20-cycle reclosing duty oil circuit breakers	82,000

Work to be advertised for bids

Schedule Number	Description	Principal Items
	Specification 8 — Riprap	
1	Riprap	1,000,000 cu. yd.
	Specification 10 — Cooper River Tail Canal	
1	Tail Canal to U. S. Highway #52	4,000,000 cu. yd. excavation
2	U. S. Highway #52 to Stony Landing.	2,000,000 cu. yd. excavation
3	Cooper River Improvement	9,000,000 cu. yd. excavation and fill
	Specification 11 to 14 — Power plant superstructure, electric wiring and switchyard.	Walls, roof, interior finish, switch boards, control equipment and wiring.

Clearing soft rock from the site of the powerhouse at Pinopolis Dam.

Camden, S. C., but large cobbles have to be brought in from Richmond, Va.

Concrete specifications are based on water-cement ratio and workability for 3,000-lb. strength at 28 days with no cement content specified. The cement is an intermediate low-heat, TVA Type B specification. Departing from current practice on large federal work, the contractor buys his own cement and his interest is allied with the owner's in securing minimum cement content, low-heat and least cracking. The concrete mixing plant contains two 2-yd. mixers and all the modern automatic equipment for weighing materials and controlling time of mix. Concrete is hauled to the job on trucks using 2-yd. buckets and is swung to its final location by cranes.

Work on the diversion canal and nearly 30 miles of long low dikes that rim a large part of the reservoir area is under way.

Clearing of the 95 sq. mi. of timberland on the Pinopolis reservoir area is being done by the WPA working from camps that are shifted as required.

Large earthmoving equipment is being used in the dams of the Santee-Cooper project, where 8,800,000 cu. yd. have to be moved into the rolled and dumped fills.

Construction of the three principal sections that make up Santee Dam is getting well under way. The contractor for the 14,200-ft.-long earth fill at the south end is making a good showing using methods similar to those at Pinopolis, but his borrow lacks moisture so that he was able to work last winter under wet conditions that shut down the other job.

The 3,400-ft. concrete spillway section is to be built out from the south side of the valley along a low ridge that lies between two loops in the meandering river. There the contractor has formed his working cofferdam by excavating with draglines down to the firm sand on which the base slab is to be laid, throwing up the rejected material along the sides to protect his work. His camp has been completed, and by the time he is ready to place concrete in May it is expected that the 13-mile railway line to the dam will be ready for operation. This line is primarily a logging road. It goes out over the contractor's cofferdam and crosses the river on a trestle to reach the Santee swamp where major lumbering operations are required in clearing the reservoir area. Arrangements are being made to have the timber cut by commercial operators.

The river will remain in its present channel until it can be diverted through openings left in the spillway. Then the channel will be closed and included in the hydraulic fill dam to the north.

Clearing and stripping for the hydraulic fill 23,000 ft. long across the flood plain to the north is nearing completion.

Nearly 6,000 people were employed on the job at the first of May.

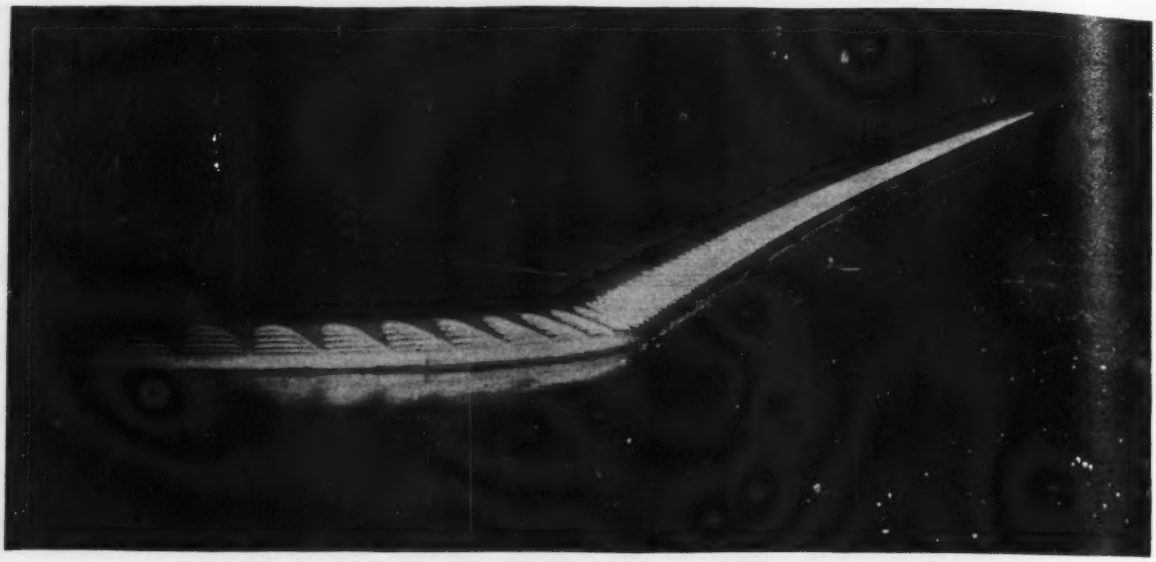


FIG. I. NEW JERSEY CURBS ARE DESIGNED TO REFLECT LIKE A MIRROR, ESPECIALLY IN THE RAIN.

Ribbons of Light

***Contents in Brief**—New Jersey has taken the lead in delineating the limits and direction of its highways by means of a unique type of curb which, because it reflects light, appears as a distinctly visible white band of light to the night driver in both dry and rainy weather. These highly efficient, latest types of reflecting curb are the result of careful study and development plus three years of actual construction experience. Costs for built in place types are little more than for smooth curbs.*

NEW JERSEY has installed well over a hundred miles of various kinds of reflecting curb since 1937, and its utilization is now standard practice in all high-type road design. The development of reflecting curb has been motivated by the realization that highway features must be clearly visible to the night driver if he is to drive safely. Observant drivers realize that much improvement is needed along these lines. To substantiate this, accident records overwhelmingly show that, in terms of miles traveled, more serious accidents occur at night than in the daytime. Except in highly illuminated areas, the higher night-time accident rate is, for the most part, the result of visibility of such a low order that the night driver is too often uncertain as to the limits, character, and direction of the road ahead. When emergencies arise under these conditions, the margin of safety for the night driver becomes critical. Until recently, practically all efforts to increase visibility have been directed toward strengthening the headlamp beams and, in a limited number of localities, providing overhead illumination. It is now recognized, however, that to attain visibility consistent with reasonable safety, certain features must be incorporated in highway structures to work in conjunction with the available light.

New Jersey's first effort toward improving the visibility of curb was made several years ago, when white concrete materials were substituted for the customary gray. Adjoining high-speed riding surfaces, a wide sloping type of curb of white concrete was constructed. The white surface was troweled smooth to reduce the collection of dirt. In the daytime the curb appeared distinctly whiter than the adjoining gray pavement surfaces, but to the night driver there appeared to be little if any difference. Moreover, observation disclosed that on rainy nights both the normally white curb and the gray surface of the pavement appeared almost totally black.

These circumstances are strikingly brought out in Fig. 2 which is a photograph of a portion of a road bordered by the smooth, white sloping curb just described. Illumination was provided by an ordinary pair of headlamps. To simulate dry and rainy night conditions in the same photograph, water was sprinkled on a portion of the curb and pavement surfaces and, as may be seen, the wet areas appear practically black. This photograph demonstrates first and foremost the pronounced loss in visibility that ordinary highway surfaces undergo on rainy nights. It is evident that the same light source illuminates both the wet and the dry areas, and therefore, that the character or condition of the surface is a function of its visibility. Regardless of how white this smooth type of curb appears in the daytime it appears almost totally black to the driver on rainy

nights. This illustrates why headlights seem to function so poorly on wet nights, and why it becomes so difficult to see the riding surface. Furthermore, an increase in headlamp strength, even above that which could be withstood by approaching traffic, would not materially increase the visibility of these wet areas.

The reasons why the smooth white curb, and the pavement surface, lose their visibility become apparent if well-known principles of light reflection are taken into consideration. Normally, light that reaches the eyes by reflection from a surface is the medium which makes one aware of the existence of the surface. The less light a surface reflects to the eyes the darker it appears. All surfaces reflect more or less, but in various ways. The direction of the reflected light rays depends upon the formation of the surface and the position of the light source. Light striking a flat, polished surface, such as a mirror, is reflected in a definite direction. But when light strikes an ordinary dry concrete surface it is reflected in many directions. The rougher the surface, the more light is dispersed. Fig. 3, left, graphically shows headlamp rays striking a troweled white concrete curb surface during dry weather. On encountering the surface at this flat angle most of the rays are dispersed in a forward and upward direction. Very little light is reflected back to the driver and consequently, even though white by daylight, the curb surface appears dark gray under these conditions. Below is shown a wet weather condition at which time practically all the light rays which encounter the surface are reflected from it in a definite forward direction. When the concrete surface becomes wet, a film of water fills in the minor depressions. The upper surface of the water, being smooth, possesses the critical reflecting properties of a true mirror, and practically all the headlight rays that strike it are reflected in a definite forward direction. The only reflected rays that reach the driver's eyes are those that penetrate the water film and are dispersed by contact with the underlying concrete. The result is that almost none of the light is reflected back to the driver and the curb appears black to him.

Fig. 3, right, shows in an exaggerated manner how a surface may be

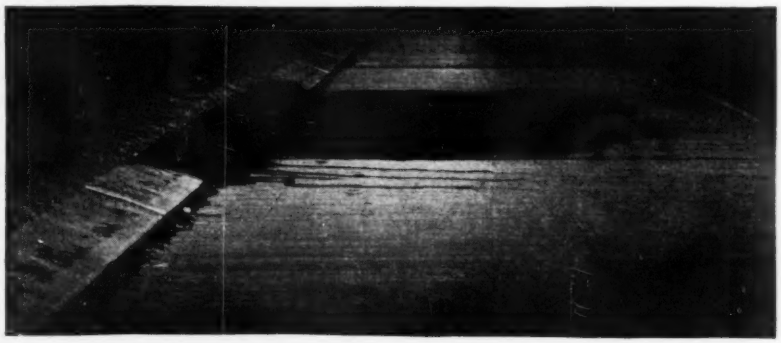


Fig. 2. Black area results from water sprinkled on dry pavement and white curb. Illumination is from automobile headlamps.

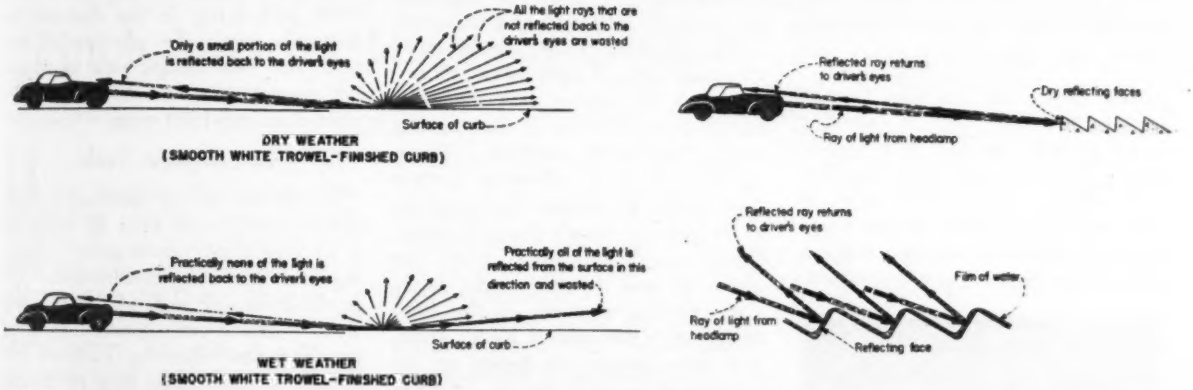

Only a small portion of the light is reflected back to the driver's eyes
All the light rays that are not reflected back to the driver's eyes are wasted
Surface of curb
DRY WEATHER
(SMOOTH WHITE TROWEL-FINISHED CURB)
Reflected ray returns to driver's eyes
Dry reflecting faces
Ray of light from headlamp
Practically none of the light is reflected back to the driver's eyes
Practically all of the light is reflected from the surface in this direction and wasted
Surface of curb
WET WEATHER
(SMOOTH WHITE TROWEL-FINISHED CURB)
Reflected ray returns to driver's eyes
Film of water
Ray of light from headlamp
Reflecting face

Fig. 3. Graphic illustration of the theory of light reflecting curbs. Note that rain on the smooth trowled surface reflects almost all of the light ahead; on proper angle faces almost all light striking the surface is returned to the driver.

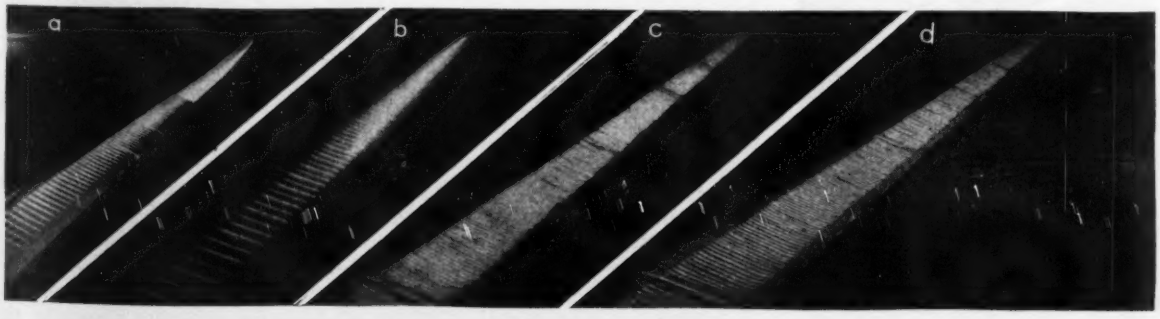


Fig. 4. (a) 1938 reflecting curb in foreground, 1939 continuing into darkness. (b) Note the gleam (on wet curb). Difference in angle of head lamps makes beam "mount" curb. (c) and (d) Rainy and dry night comparison of curbs. The concrete and painted stripe are blacked out on wet night.

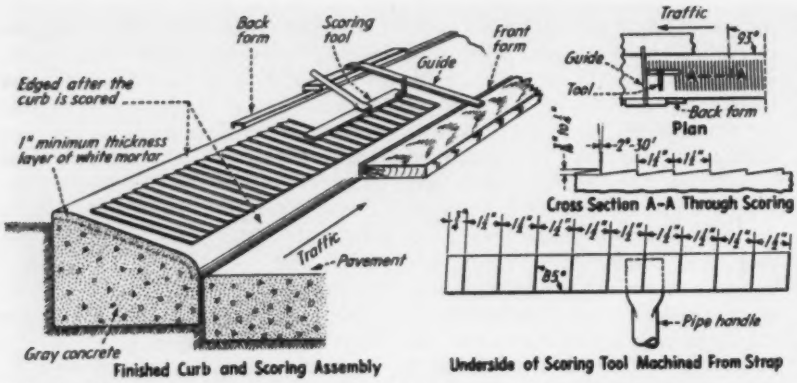


Fig. 5. Details of scoring and tools required for poured in place sloping reflecting curb developed by New Jersey highway department.

formed so as to reflect light back to the driver. In principle, the surface as a whole consists of a series of small reflecting surfaces which lie approximately perpendicular to the headlight rays. During both dry and wet weather, concrete surfaces constructed in this manner are considerably more visible than ordinary smooth surfaces. The presence of the water film adds greatly to the light-reflecting properties of these surfaces. When properly formed, these surfaces are distinctly more visible on wet nights than on dry—which is just the opposite of what takes place in the case of ordinary smooth concrete surfaces.

Two types of curbs

New Jersey has installed two essentially different types of reflecting curb; namely, precast and cast-in-place. Precast curb lends itself to very accurate control both as to design and manufacture. Before a precast curb design is adopted study is given to its theoretical requirements.

Fig. 6. Cast in place barrier curb in an overhead lighted area. Upper view is dry condition with effect of rain shown below.

In order that a series of reflecting faces may be utilized to the best advantage it is necessary that they be slightly curved in plan and have a small amount of vertical warp coordinated with the curvature. The resulting warped curved surface is such that a small portion of each reflecting surface on the curb is always correctly positioned with respect to a vehicle travelling in a normal position adjacent to the curb. The accuracy and selection of the reflecting surfaces as to spacing, height, and curvature, greatly influence the result during wet weather. If the faces are properly designed and manufactured, they will reflect one or more gleaming lines of light when wet.

Fig. 4 (b) shows this gleaming line on a short stretch of curb having convex reflecting surfaces. Those portions of each reflecting surface that satisfy theoretical requirements in the position chosen gleam brightly. Other vehicle positions move the gleam to new points on the faces. The reflecting surfaces on the 1940 design curb are spaced 3½ in. apart, and three variants of design are incorporated in each 10½ in. of curb. The gleaming area is spread and increased over that shown.

Manufacture of precast slabs

In the manufacture of the slabs, a short section of curb of plaster of Paris is first made, usually 10 or 12 in. in length, to which are attached the desired reflecting surfaces. The reflecting surfaces, which are also of plaster, are accurately finished mechanically and attached to the larger backing piece. A short plaster mold is obtained from this original built-up section. A series of plaster sections are then cast in this mold, laid end-to-end, joints closed, and a full-length plaster master obtained. A form is placed around the plaster master, which is usually about ten feet long in the case of straight curb, and filled with concrete. Several days later the plaster master is chiselled out of the resulting concrete mold. The concrete mold thus obtained is used to make several sections of curb for testing purposes, and also to make master sections of curb from which curb manufacturers make similar molds in concrete. The interiors of the concrete molds used for precast curb manufacture have a very smooth, glassy surface. Straight curb is manufactured in lengths of about 9 ft. Contracts are normally let for the curb in place on the road. Contractors have the slabs made at nearby commercial plants from master sections made in the state laboratory. A description of some of the general and curved end designs and construction procedure is given in *ENR*, March 14, 1940, page 62.

Fig. 4 (a) is indicative of the increased efficiency of the designs as experience has been gained. This picture, taken on a rainy night under ordinary headlamp illumination, shows the juncture of a section of 1938 curb with that of 1939. The 1939 curb lying in the distance is distinctly the more efficient of the two. The 1940 design, now undergoing manufacture, is still more efficient than the 1939 type.

Cast-in-place curb

In addition to the above described precast curb, more than 40 miles of a sloping type cast-in-place reflecting curb has been constructed. Approximately one inch of the exposed surface of the curb consists of mortar, and the reflecting surfaces are formed in the mortar face by means of a hand scoring tool, in the manner shown in Fig. 5. This is probably the easiest and cheapest type of sloping reflecting curb to produce because it is free from the many difficulties and problems that are incidental to precast curb manufacture of complex design. Its cost, in fact, is approximately the same as smooth troweled curb, once the proper equipment is secured; and the value of the results obtained far exceed the effort required to build it. Because of the method employed it is not possible to form the reflecting faces with the same degree of accuracy obtainable in precast work. However, the re-

flecting band appears very white in both dry and wet weather.

Fig. 4 (d) shows how the scored curb appears on dry nights. Note particularly that the pavement surface and the white painted line, though fairly visible on dry nights, disappear in the rain, and that the curb, while not showing the gleam, does produce a well-defined guide to the road ahead. Experiments are being made to increase the efficiency of the tooled-in-place curb. Most likely improvement to date is addition of vertical guides to the hand tool and "straight lining" of the edging by operation of a tool extending across the curb form tops rather than by eye. Depth of the vertical face will be ¼ in. or more.

Vertical curb

Reflecting curb of the ordinary vertical type, shown in Fig. 6 on a dry and a wet night, is also constructed. This is poured-in-place on the job, as the nearly vertical face permits complete contact with the form and puddling releases the entrained air to give a dense surface. The series of reflecting surfaces in the front face are obtained by a metal form which takes the place of the ordinary front form usually used in vertical curb construction. Because of the complexity of the design, considerable difficulty was originally experienced in developing a form that would be light and cheap enough to make this type of curb efficient and economical. A front form, consisting of a series of die-cast zinc alloy sections, attached to a metal backing, was finally devised. This type of form has given excellent results and, because it is substantially fabricated, its first cost may be charged off to many miles of curb. It is made in 10-ft. sections for straight and long radius curb. Shorter lengths are utilized where the sharpness of curvature requires it. Once an expenditure is made for a set of these forms, reflecting curb of this type may be constructed at approximately the same cost as ordinary smooth curb.

Considering the surprising increase in visibility resulting from the application of essentially simple curb design principles, it appears evident that a distinct forward step toward increasing night-time visibility and safety will be made when the same basic ideas are incorporated in the design of pavements, traffic markers, and other highway structures.

Personnel

Development of the reflecting curb has occurred in the New Jersey State Highway Department laboratory under the direction of E. Donald Sterner, commissioner, and James Logan, highway engineer. Direct work on the development has been under Harold W. Giffin, engineer of survey and plans, and William Van Breeman, engineer of special assignments (in charge at the laboratory), who have furnished the information for this article.

Fraser River Transporter Ferry Pinch Hits for Highway Bridge

HIGHWAY COMMUNICATION with the outside world has been provided for the little town of North Bend, B. C., by a transporter ferry which conveys automobiles, one at a time, across the Fraser River to the Cariboo Highway on the opposite side of the canyon. The span is 1,200 ft., the transporter carriage is supported on two 1¾-in. cables and power is supplied, through a ⅛-in. hauling line, by a hoist operated by a gasoline engine. This hoist had been used on other work and was available near the site when the project was put through.

North Bend is on the Canadian Pacific Railway, 132 miles east of Vancouver, B. C. Heretofore the town has been accessible in wintertime only by rail and there has been increasing demand for some means of getting automobiles across the river to the Cariboo Highway which follows the opposite side of the canyon. The ordinary auto ferry would not be satisfactory here during the heavy runoff period because of the steep banks and the 40-ft. fluctuations in river level with the attendant problem in approaches to a water-level ferry.

Transporter ferry, capacity one automobile, crossing the Fraser River canyon.

Ferry carriage

The transporter ferry consists of a steel carriage operating on two main cables, 20 ft. apart, and has a capacity sufficient for a loaded one-ton truck. The cables pass over a tower on one side and concrete piers on the other; the traveler from which the carriage is slung operates on two wheels equipped with roller bearings and rubber cushions. The 1,200-ft. trip is made in about 4 min.; the operating staff consists of two men, one at the hoist and one riding in the carriage.

Plans for the transporter ferry were developed by the bridge department, Department of Public Works, Victoria, B. C., and were carried out under the direction of the Hon. C. S. Leary, minister, and A. Dixon, deputy minister and chief engineer.

FIG. I. THOUSANDS OF SAMPLES OF RIVER WATER WILL GIVE A CASE HISTORY OF THE "POISONED" OHIO RIVER.

Diagnosis for a Sick River

EDWARD J. CLEARY
Associate Editor, Engineering News-Record

Contents in Brief—Now under way in the Ohio River drainage basin is perhaps the greatest stream sanitation study ever attempted. No precedent existed for work of this magnitude, involving an area of 204,000 square miles included in 14 states. As described herein, the organization of the survey, its methods and its objectives provide a new chapter in stream pollution abatement progress. A second article will deal with the mobile laboratories used on land and water.

RIVERS, LIKE HUMAN BEINGS, get sick when they are poisoned. And the sickest river in this country is the once "beautiful Ohio." Dosed with sewage and industrial wastes, the Ohio River and all the tributary streams in its drainage area are at last receiving the attention to which a sick patient is submitted before remedial measures can be applied. A diagnosis is being made by the U. S. Corps of Engineers and the U. S. Public Health Service under the general direction of the Ohio River Committee, which was appointed at the request of the President.

In undertaking this "diagnosis" the federal government is engaged in a stream pollution survey the scope of which has no precedent. The task is one of fact finding—in an area of 204,000 square miles drained by a river almost 1,000 miles in length—to determine a plan of procedure for stream cleanup. Fact finding in this case involves, among other things, the Herculean task of gathering thousands of river samples to each of which a half dozen or more chemical and bacteriological tests are applied. Further, it calls for the assembly of data on sources of pollution, streamflows, population, industrial activities and existing waste treatment facilities. And following this comes the final exceedingly complex problem of interpretation and application of the findings.

It has not been the magnitude of the job which so long delayed its undertaking, however. Rather, it was the lack of federal government authorization which is necessary in order to make a comprehensive study of pollution problems in a drainage basin which includes portions of fourteen states. This authorization was given in the Rivers and Harbor Act of August, 1937, which provided that the Secretary of War "cause a survey to be made of the Ohio River and its tributaries to ascertain what pollutive substances are being deposited, directly or indirectly, therein and the sources and extent of such deposits and with a view to determining the most feasi-

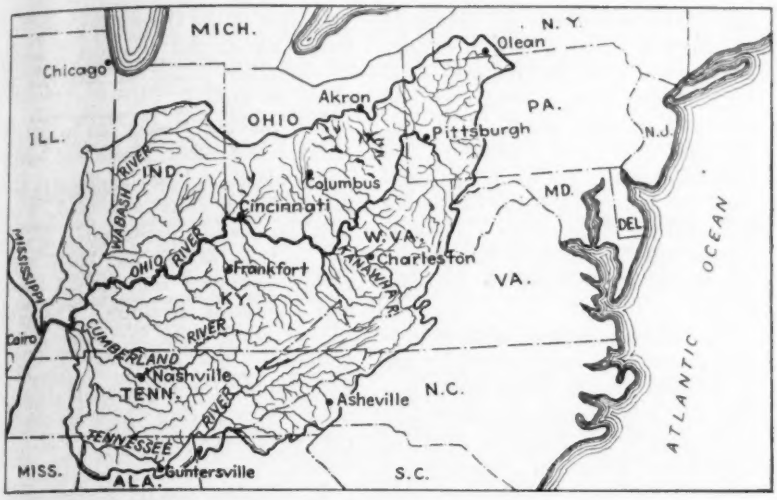


Fig. 2. Drainage basin of the Ohio River and its tributaries. The pollution survey involves an area of 204,000 square miles in 14 states.

ble method of correcting and eliminating the pollution of these streams."

At the request of the Secretary of War the Public Health Service was authorized to undertake the following parts of the study:

1. Make laboratory investigations
2. Collect factual data on pollution
3. Determine the character of water in the main and tributary streams
4. Determine the extent of treatment required
5. Carry out all other necessary studies to determine existing and future conditions bearing on pollution.

Hydrometric data to be used in the survey will be furnished by the U. S. Corps of Engineers, who not only have records of many years' standing but who are also specially qualified to carry on complex studies of streamflow.

In contrast to previous sanitary studies made on streams—which have been largely of a research character designed to reveal information on the self-purification of running water—the Ohio River survey is directed toward the practical objective of determining what conditions are, and recommending the means by which they should be improved.

Organized for efficiency

It should be clear that the Ohio River survey is not a one-man job or an undertaking suited even to the existing facilities of a single organization. Because funds are limited and since it is desired to complete the work within the relatively short period of two years, special attention was given to the development of an efficient organization. The plan evolved is designed to integrate the efforts and facilities of federal agencies and, wherever possible, enlist the cooperative aid of state health departments. The latter, having worked with the Public Health Service for over 20 years, serve as liaison agents in contact with municipal officials and industrial establishments, as well as furnish data on local pollution problems.

To provide for coordination of this work, an Ohio River Committee was appointed by the President. The three members are: Gen. T. M. Robins of the Corps of Engineers; Senior Sanitary Engineer R. E. Tarbett, of the Public Health Service, and Abel Wolman, professor of sanitary engineering at Johns Hopkins University, a non-government expert on pollution problems.

As shown in the accompanying organization chart, the work of the survey is a joint undertaking of the Corps of Engineers and the Public Health Service. The Corps of Engineers has centered its activities in the office of the Division Engineer at Cincinnati, where the hydrometric studies will be concentrated, and

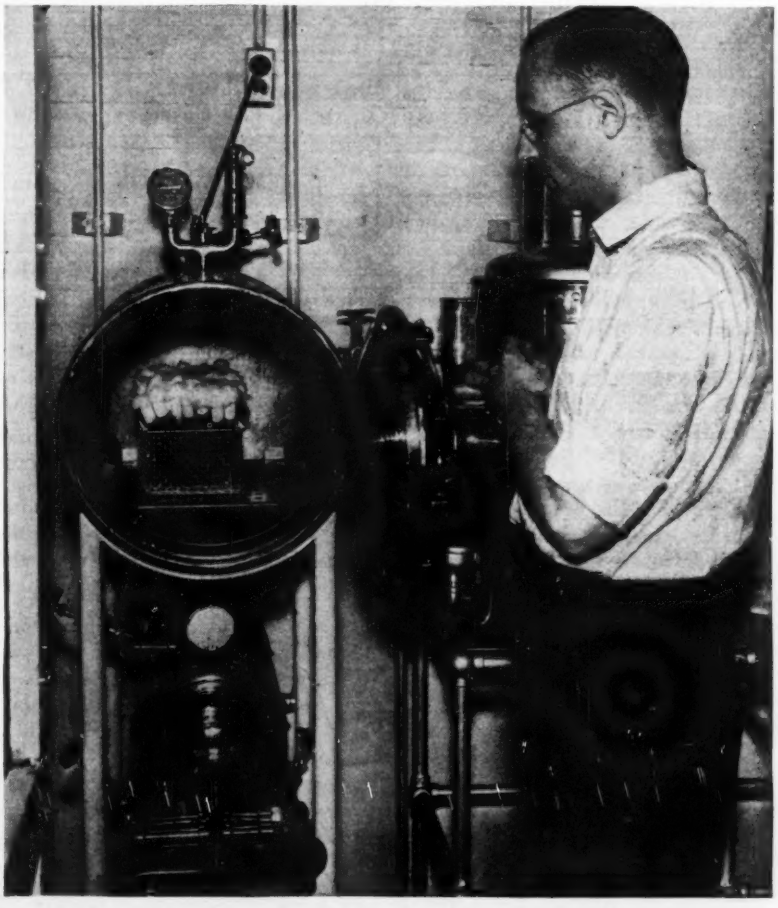


Fig. 3. Sterilizing the "broth" into which samples of river water will later be placed for bacterial examinations.

where it will be in close contact with the Public Health Service laboratories and offices.

What is being done

General Plan—Preliminary estimates indicated that it would require three years to complete the survey. During the first year (1939) the work was confined to the middle third of the main river, a section of about 280 miles extending from the mouth of the Kanawha River to the mouth of the Kentucky River, embracing some 50,000 square miles in area, and the Cumberland and Tennessee rivers.

The 1940 investigations will cover approximately 140,000 square miles, including the upper and lower portions of the Ohio River Basin. In the upper portion is included the 260-mile stretch of the Ohio between Pt. Pleasant, W. Va., and Pittsburgh, Pa. Observations will be made on the Allegheny and Monongahela rivers, whose confluence at Pittsburgh forms the Ohio River. Also included in this year's program is the large drainage basin of the Wabash in Indiana and the Illinois north of the Ohio River and completion of the work on the watersheds of the Cumberland and Tennessee rivers to the south.

Laboratory Studies — Analytical data which will show the degree in variation of pollution both chemically and bacteriologically, requires careful sampling over a wide area and prompt laboratory examination. For the main river survey, therefore, two base laboratories are used. The principal one is located at the Cincinnati headquarters. This serves a 140-mile section from Maysville to Carrollton; operations here began in January, 1939.

The other principal laboratory is a large two-deck quarterboat for use at various points along the Ohio River. This boat, loaned by the Corps of Engineers and formerly used for quartering personnel engaged on river operations, has been converted to provide complete laboratory facilities as well as office and living accommodations for a survey staff of eleven engineers and technicians. Details of the floating laboratory and mobile land units will be given in an article to follow.

Samples from the main river and from the mouth of tributaries are collected with the aid of automobiles and motorboats; one each of the latter is assigned to the Cincinnati and floating base laboratories. Additional samples are taken just upstream from each of the government dams which form part of the Ohio River canalization scheme; this provides a series of sampling points at intervals of about 20 miles.

For making studies on tributary streams and other places not easily accessible to a base laboratory, two mobile field units are used. Each unit consists of an automobile towing car and a trailer, the latter completely equipped with special bench and laboratory facilities. The plan of operation calls for locating the trailer in the center of an area under study for a period of two or more weeks, during which the towing car collects samples within a 40-mile radius.

In addition, special studies of industrial wastes are being carried on in cooperation with the stream pollution unit of the Tennessee Valley Authority in its laboratory at Muscle Shoals.

Field Surveys—These investigations deal with the collection and assembly of factual data relating to pollution by sewage and industrial wastes. Engineers of the Public Health Service, cooperating with state health departments, are gathering information on water users, types and condition of water supply and sewage disposal facilities, and perhaps of greatest importance, industrial wastes. In connection with the latter, investigations have already been made of some 550 industrial plants, and these reveal that provisions for treatment and disposal of such wastes will be an outstanding problem. Recognition of this fact has led to the preparation of a manual for each type of industry in which will be incorporated all the information available showing quantity, quality, and known methods of treatment of various types of wastes.

Already preliminary drafts of manuals for seven industrial wastes (brewery, tannery, pulp mill, paper mill, corn cannery, slaughter house and packing house, milk plant and distillery) have been completed and these have been submitted to chemists and engineers for suggestions and revision. Eventually the manuals should serve as guides for the development and installation of satisfactory industrial waste disposal facilities throughout the nation.

Acid mine drainage, one of the principal sources of Ohio River pollution, has for some time received the attention of the Public Health

Fig. 4. Organization chart of the Ohio River Board, under whose direction the Corps of Engineers and the U. S. Public Health Service are cooperatively engaged on pollution studies.

Service working in an advisory capacity with the Work Projects Administration. Therefore, it will not be necessary to investigate and report on this phase of the field studies since adequate data are already available.

Hydrometric Studies—The important job of securing detailed information on the volume of the flow of the streams of the drainage basin is being carried out by the U. S. Corps of Engineers. The work includes analysis of past flow records, compilation of daily flows during the period of the survey, and preparation of estimates of future conditions of average and abnormal amounts of flow.

Progress and results

In the first year period ending Dec. 31, 1939, field surveys of pollution sources and of public water supplies were completed in the area under study; 23,329 river water samples were collected, on which 42,348 laboratory tests were made. In considering these figures, however, it should be recalled that the floating laboratory did not go into service until May and the mobile units until August of 1939.

While it is not practicable to draw conclusions from results thus far obtained, some general trends can be evaluated. These are revealed in the statement by H. W. Streeter, senior sanitary engineer of the Public Health Service, who is directing the laboratory studies. Mr. Streeter says:

"Comparing the Ohio River water in the middle third section with respect to its suitability for purification by ordinary rapid sand filtration coupled with postchlorination, it is roughly estimated that under the most unfavorable monthly mean conditions of 1939 about 35 per cent of the waters examined would be considered as suitable for treatment, 20 per cent as doubtful in this respect, and 45 per cent as clearly unsuitable.

On the basis of dissolved oxygen content, about 40 per cent would be rated as satisfactory, 20 per cent as doubtful, and 40 per cent as clearly unsatisfactory. Thus it appears, from the two criteria combined, that about 35 to 40 per cent of the waters examined during August were in reasonably good sanitary condition, the remainder being either grossly polluted or of doubtful quality reflecting conditions requiring correction.

"The tributary observations made thus far (in the middle third area) show that in all of the drainage areas degrees of pollution ranging from moderate to gross have been observed below most of the shore towns and industrial centers. In some of these cases both primary and secondary treatment of waste will be required to restore favorable conditions."

Blazing a new trail

The Ohio River survey is blazing a new trail in pollution abatement progress. It brings together for the first time a group of federal agencies to combine their special skills and equipment in making a comprehensive study of river uses and abuses. But it goes still further in also correlating the services and interests of state health departments, municipalities and private industry in a planned program leading to the adoption of remedial measures.

Viewed from its technical aspects, the survey is likewise a pioneer venture. Never before has an attempt been made to make a sanitary engineering investigation on this scale. The techniques applied and the lessons learned will be a contribution of great practical significance.

In an article to follow the trailer and floating laboratories will be described.

Radio Improves Aneroid Efficiency

E. A. Bailey
Hydraulic Engineer, Tennessee Valley Authority, Knoxville

Making preliminary studies of dam and reservoir sites for the Tennessee Valley Authority involves the necessity of determining with fair accuracy the elevation of proposed pool levels along the reservoir rims. Such a case presented itself to the writer recently when the geologist's approval or disapproval of a certain site depended on whether or not the waters of the reservoir would reach up certain small creek tributaries far enough to inundate a marble belt which is full of sink holes. No accurate contour map covering this area was available, nor were benchmarks within a reasonable distance for economical differential leveling. For this reason a means of using an aneroid for fairly accurate level determination was sought. Because barometric pressure changes result in as much as 100-ft. variation in aneroid readings during a day, a means of maintaining control is necessary to the success of such surveys. Radio is the logical answer to this requirement.

Knowing of the satisfactory results obtained from the authority's system of short-wave radio river gaging and rainfall stations, the writer obtained the services of an operator and a set of the radio equipment developed for a river gaging station. The operator and his equipment were left at the nearest benchmark. At this point he read a Paulin aneroid barometer and changed the setting on the sending apparatus every time the barometer reading changed as much as 10 ft.

With a radio receiving set in a car, the geologist and the writer proceeded over farm roads to each of the creeks in question. They listened for the correction, then walked up the creek to the desired level, returned to the car and listened again to see how much the correction had changed, so as to judge the accuracy of the level determined up the creek. In this way, five creeks were tested and the geology therein outlined in one day, resulting in approval of the damsite for survey and test boring.

It should be possible to develop a barometer, permanently installed, which would automatically change the correction, so that no attendant would be necessary. With such an installation, any day on which such barometric radio service is desired by any of the field forces using an aneroid barometer, it could be secured simply by closing a switch to cut in the sending apparatus. Such a service could increase the efficiency of field work wherever aneroid barometers are extensively used.

Building a Big Sewer In Bad Ground

WILLIAM B. FOWLER
City Engineer, Memphis, Tenn.

Contents in Brief *— To build an intercepting sewer paralleling the river front at Memphis compressed air tunneling methods were required. A modified horseshoe-shaped reinforced concrete sewer was installed to handle a flow of 27 mgd. Construction methods and plant were carefully specified to insure good workmanship.*

CONSTRUCTION of a large intercepting sewer in Memphis to remove pollution from the harbor and divert sewage to a point downstream from the city called for the use of compressed air tunneling methods with pressures ranging from 2 to 28 lb. per sq. in. Some 14,000 ft. of horseshoe-shaped concrete sewers were recently completed through water-bearing sand, clay and gravel formations along the east bank of the Mississippi River. The sewer sections varied in size from 5.8 x 6.3 ft. to 7.4 x 7.8 ft. To expedite the work, tunnel headings were driven from three shafts. The following is a description of the design factors affecting the sewer installation as well as the methods of construction.

Memphis Harbor is at the mouth of the Wolf River which, in its lower reaches, receives the sewage from about 65 per cent of the city's population. Nine outfall sewers discharged directly into the Wolf River and one outfall just below the mouth of river discharged into the Mississippi; the average sewage flow amounted to 27 mgd. The new sewer was designed to intercept all of these outfalls and carry the sewage to a point downstream from the city. (Fig. 2).

Sewer design data

The barrel of the sewer is of reinforced concrete, designed for construction in tunnel, and is of the modified horseshoe shape, the ratios of the radii of the interior crown, wall and invert faces to the inside height being as follows:

Crown	0.30
Walls above springline	0.91
Walls below springline	0.45
Invert, or floor	1.125

The dimensions of the three typical barrel sections are shown on Fig. 3. The sections were designed to carry the full load of the prism of earth of the outside width of the barrel at the springline and of the depth of the crown below the ground surface, with an additional loading equivalent to the hydrostatic head of the groundwater above the springline. The depth of the cover over the crown of the sewer barrel is from 21 to 95 ft. The gradients and carrying capacities of the various lengths of the sewer are shown in Table I.

TABLE I—GRADIENTS AND CAPACITIES OF SEWER SECTIONS

Section	From	To	Area of Section Sq.ft.	Hydraulic Radius	Gradient	Carrying Capacity C.f.s.
C	Raffaraus	Auction	28.9	1.475	.0003	88
B	Auction	Monroe	44.2	1.825	.0003	160
B	Monroe	Union	44.2	1.825	.0005	208
A	Union	Huling	44.2	1.825	.0005	208
A	Huling	River	44.2	1.825	.0006	230

The elevation of the sewer with relation to the Mississippi River is such that the sewer barrel will be submerged when the river stage is but 14 ft. above the normal low water stage. Submergence of the barrel, however, will not interfere with its

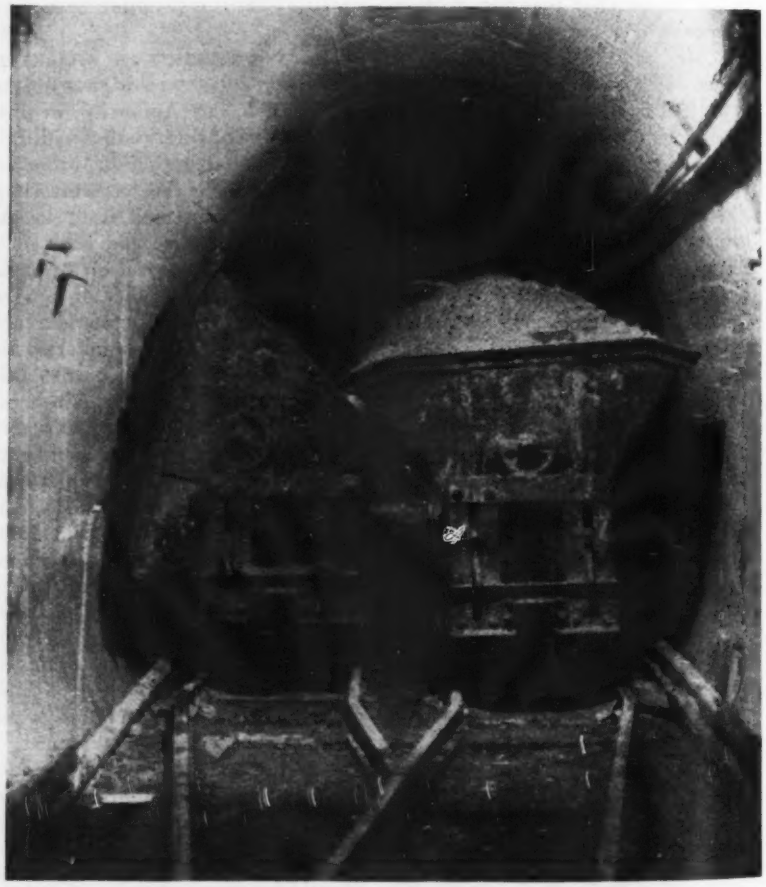


Fig. 1. Where inches count. Switching arrangement in the Memphis sewer tunnel which made it possible to pass loaded and empty gondolas in a narrow space.

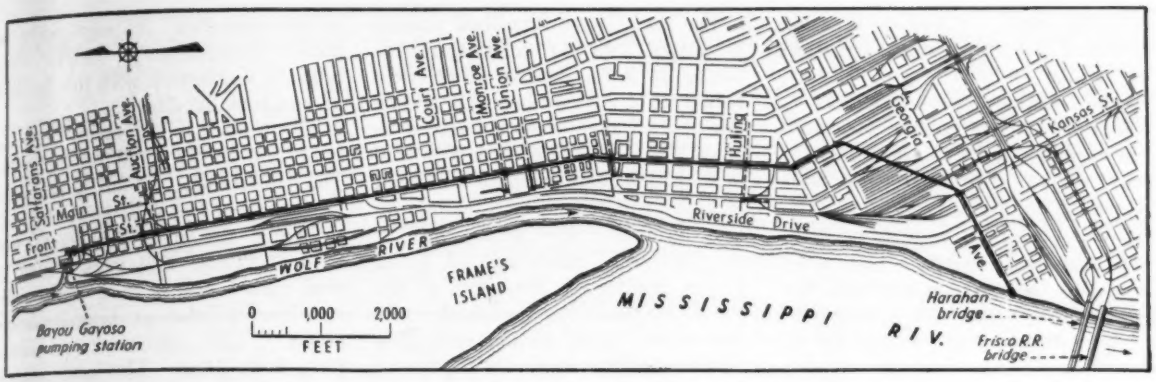


Fig. 2. Route of the intercepting sewer, the construction of which was carried on from three shafts.

operation nor materially reduce its capacity until flood stage (34 ft., gage) is reached, because of the fact that all contributing sewers are at elevations above this stage, or can be by-passed to the pumping station where the sewage will be forced back into the new sewer.

Two gate structures, equipped with hand-operated sluice gates have been provided on the new sewer, to be used at extremely high river stages to prevent the backing up of river water into the contributing sewers. One of these, located at Monroe Ave., will be closed at Stage 41, and the other, at Kansas St. and Georgia Ave., will be closed at Stage 51. With the former closed, all sewage reaching the interceptor above this gate will be backed up to the pumping station and pumped over the levee into Wolf River, while the sewage reaching the interceptor below this gate will continue to flow to the Mississippi outlet. With the latter closed, all sewage will be pumped over the levee into Wolf River.

Construction plan

Construction of the project went forward under three contracts, with a construction shaft and surface plant for each contract. The character of the material penetrated by the sewer barrel being largely sandy clay, sand, gravel and river silt, all water-bearing, the project was built by compressed air tunneling methods. Air pressures in the headings ranged from 2 to 28 lb. per sq. in.

The surface plant at the Court Ave. shaft, which was typical of the others, included a compressor house, "hoghouse", office, concrete batching and mixing plant, shaft head-house and tipple structure, in addition to concrete aggregate, reinforcing steel, liner plate and other stockpiles. All buildings were of steel framing with steel walls and roofs and concrete floors—a definite requirement of the specifications.

The working shaft was rectangular in plan, tight-sheeted with interlocking steel sheetpiling supported by steel H-beam walers and struts. The shaft was 80 ft. deep, and the dimensions inside the sheetpiling were 15.3 x 18.7 ft. above a level 66 ft. below the ground surface; from that level to the bottom the dimensions were reduced to about 12 x 15.5 ft. The lower part of the shaft was enclosed and retained by driving vertically 10-in. wide-flange steel beams on 3-ft. 8-in. centers to a depth 5 ft. below the subgrade level, then placing 3-in. hardwood lagging back of these members and steel waler sets in front of them as the excavation was carried down.

After excavation was completed and the shaft bottom concreted, the panels between the vertical beams were filled with concrete suitably reinforced to transmit the earth pressure to the vertical beams. The shaft was equipped with a steel stairway and a motor-driven elevator with enclosed cage and tower. The stairwell and elevator tower were separated by a steel partition, and the head of the shaft was enclosed by a steel housing. The space between the stairway and elevator tower was used for the duplicate low pressure air lines, water lines, conduits for electric circuits, telephones, etc.

High and low air equipment

The compressor station housed four 17x10-in. horizontal low- pressure compressors, three of which are driven by 60-hp. electric motors, and the other by a 55-68-hp. diesel engine. These four units were of equal capacity, providing duplication both as to compressor capacity and as to power source. There were also two motor-driven high-pressure compressors for furnishing air for air tools and grouting machines. The compressor building also housed the electrical control board, upon which were mounted the controls for the motor-driven compressors, the concrete mixing plant, the shaft elevator, tunnel and shaft lighting circuits and the lighting circuits to the plant buildings.

Each low-pressure compressor pumped air into a receiver, from which a 6-in. pipeline carried the air to an after-cooler and thence down the shaft to one of the duplicate air headers in the tunnel. There was complete duplication of the tunnel air system, from the power source to the heading sides of the locks in the tunnels. Pressure in the receivers was normally held at 30 lb. Pressure-reducing valves in the air lines between the receivers and the aftercoolers reduced the pressure to that required in the headings. Recording pressure gages showing the pressure in the tunnel locks, and indicating gages showing the pressures in the headings were mounted in the compressor house.

The workmen's quarters building, or "hoghouse", was 20 by 68 ft. It was divided into two locker rooms providing separate facilities for white and colored employees. The building was sealed on both the walls and the ceiling with rigid insulating board, and heated by gas stoves to maintain a minimum temperature of 70 deg. A first aid center was maintained for treating minor injuries, and as a storage space for five gas masks required to be kept at each

working shaft. A medical lock was installed for the treatment of cases of "bends".

The concrete plant included a weighing batcher having a 6-cu.yd. bin capacity, and a motor-driven six-bag mixer. The aggregates were loaded from the stockpiles into the batcher bins by means of a crane and clamshell bucket. The mixer discharge chute was so arranged that it could discharge into a drop pipe in the shaft or into cars on the elevator platform. Concrete quality was closely controlled, the weighing and mixing being under the direct supervision of a materials testing engineer. Test cylinders showed that the quality and strength of concrete were uniformly well above the minimum required by the specifications, viz., 2,400 lb. per sq. in. at 7 days, and 3,000 lb. per sq. in. at 28 days.

Steel braces and liners

To eliminate the hazard of fire in the tunnel, it was required that only steel plates and steel shapes could be used for lining and bracing the bore until the concrete lining was placed. It was also required that the tunnel excavation be trimmed to such size and shape as would permit the placing of the full concrete section inside of any indentations in the steel plates, and that flanges and shapes used as ribs in the steel lining would not extend into the neat concrete section more than 3 in. These considerations led to the adoption of a corrugated steel liner plate, pressed from No. 11 gage sheets to the exact contour of the concrete lining, these plates supported on 4-in. steel I-beam ribs.

The plates were furnished pressed to shape, with the sides and ends turned to form flanges which were bolted to the rib members and to each other when they were assembled in place. The lining thus formed proved to be of adequate strength and tight enough to prevent the inflow of running ground. The lower ends of the ribs were supported on wood blocks resting on the sand at the tunnel subgrade level. Trench jacks across the tunnel at the springline were used where necessary to prevent lateral displacement of the ribs.

The methods used in mining varied in the several headings, their selection depending upon the character of material encountered. Where the crown was in loose sand, a modified poling board method was used. For the greater part, however, the character of the material was such that the crown plates could be placed without poling boards or other special methods. The bench was usually dense and hard enough to require the use of air spades. The rate of progress averaged 16 ft. per day in each heading, with an occasional day's drive of 20 ft.

The transportation system in the tunnel consists of steel mine-type cars, of ¾-cu. yd. capacity, operating on 18-in. gage industrial track, and pulled by electric storage battery locomotives. Concrete was delivered from the mixer at the top of the shaft into a vertical steel pipe, 10 in. in diameter, equipped with a lever-operated valve at the bottom of the shaft where it could be drawn into the mine cars and hauled to the headings. The entire batch from the mixer was discharged into the pipe at one operation. No segregation or other unsatisfactory results were noted in connection with this method of concrete handling.

The tunnel lining forms were of steel, and of the hand-handled type. The rib-sections, 12 in. wide, were fabricated of two 6-in. steel channels to which the steel skin plate was welded. These ribs were bolted to steel curb forms at their lower ends and were jointed or hinged at the crown. The intermediate panels were 4 ft. long. The curb panels were held in place by struts made up of 4 in. channels, which were supported on two 6-in. I-beams spanning from a bearing on the concrete invert, poured in the previous day's operation, to a steel bulkhead at the forward end of the new pour. Concrete was placed in the forms by hand shovelling, and compacted by means of internal vibrators. The invert and arch were poured monolithically in four of the six headings and separately in two headings. The forms were left in place for 24 hr. and then removed, cleaned, inspected and repaired before re-use. The rough handling which they received while being removed made it necessary to do a considerable amount of repair work.

The sewer outlet structure is a concrete slab, monolithic with the sewer barrel, enclosed in steel sheet-piles. It projects into the river about 50 ft. from the low-water shoreline and is 120 ft. long by 10 ft. wide inside of the piling enclosure. Piling was driven to the neat lines of the structure, using 65-ft. piles to provide the required penetration below the riverbed, and the tops projected

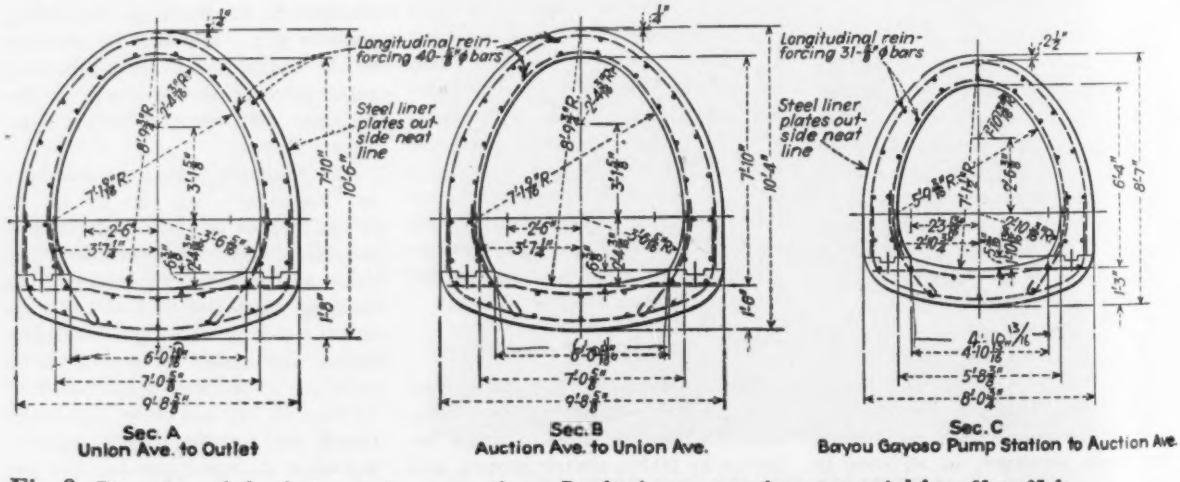

Longitudinal reinforcing 40-⅞" ϕ bars
Steel liner plates outside neat line
Longitudinal reinforcing 31-⅞" ϕ bars
Steel liner plates outside neat line
Sec. A
Union Ave. to Outlet
Sec. B
Auction Ave. to Union Ave.
Sec. C
Bayou Gayoso Pump Station to Auction Ave.

Fig. 3. Dimensions of the three typical sewer sections. Depth of cover over the crown varied from 21 to 95 ft.

19 ft. above low water to serve as a cofferdam. After the concrete structure was completed, the steel piling was burned off to the slope of the riverbed by means of a hydrogen torch operated by a diver.

The contractors on this project were Walsh and Wells, Inc., of St. Louis, Mo., who built Section I, involving the construction of about 4,000 ft. of sewer; and the Nolan Construction Co. of Detroit, Mich., who held contracts for about 10,400 ft. of sewer. Contracts were awarded in January, 1938, but little progress was made until midsummer. The work was completed in June, 1939. The cost of the project was $1,768,000, part of which was financed by a PWA grant.

The project was carried out under the direction of the writer. Black & Veatch, consulting engineers, of Kansas City, Mo., prepared the plans and specifications and supervised construction; John J. Cameron was in charge as project engineer. L. L. Pearsall was the resident engineer inspector for the Public Works Administration.

Making Walls Sound-Proof

MICHAEL RETTINGER
RCA Manufacturing Co., Inc.
Hollywood, California

Contents in Brief—In radio studios and stages for motion picture production the design objective is to get a wall and roof construction with a high sound transmission loss. Timber-framed walls covered with various combinations of rockwool and fiberboard and utilizing air spaces and isolator fastenings are most widely used. Tile is better than plaster for absorbing interior noises.

THE TERM sound-proof wall may be applied to any space-confining partition which lowers an existing noise level to an extent necessary to permit the satisfactory performance of the activity for which the enclosure is intended. It is therefore a relative term which for a home, where doors and windows probably constitute the limiting factors toward sound insulation, may mean a wall having a transmission loss of 40 decibels (db.); while for a radio studio or a motion picture sound stage it may mean a wall with a markedly higher degree of insulation.

Measuring sound transmission

The numerical measure of the reduction of sound intensity is given by the term "transmission loss" which is defined by the American Standards Association as "ten times the logarithm to the base 10 of the reciprocal of the transmittivity T which in turn is the ratio of the rate of transmitted sound energy away from the partition to the rate of flow of incident sound energy.

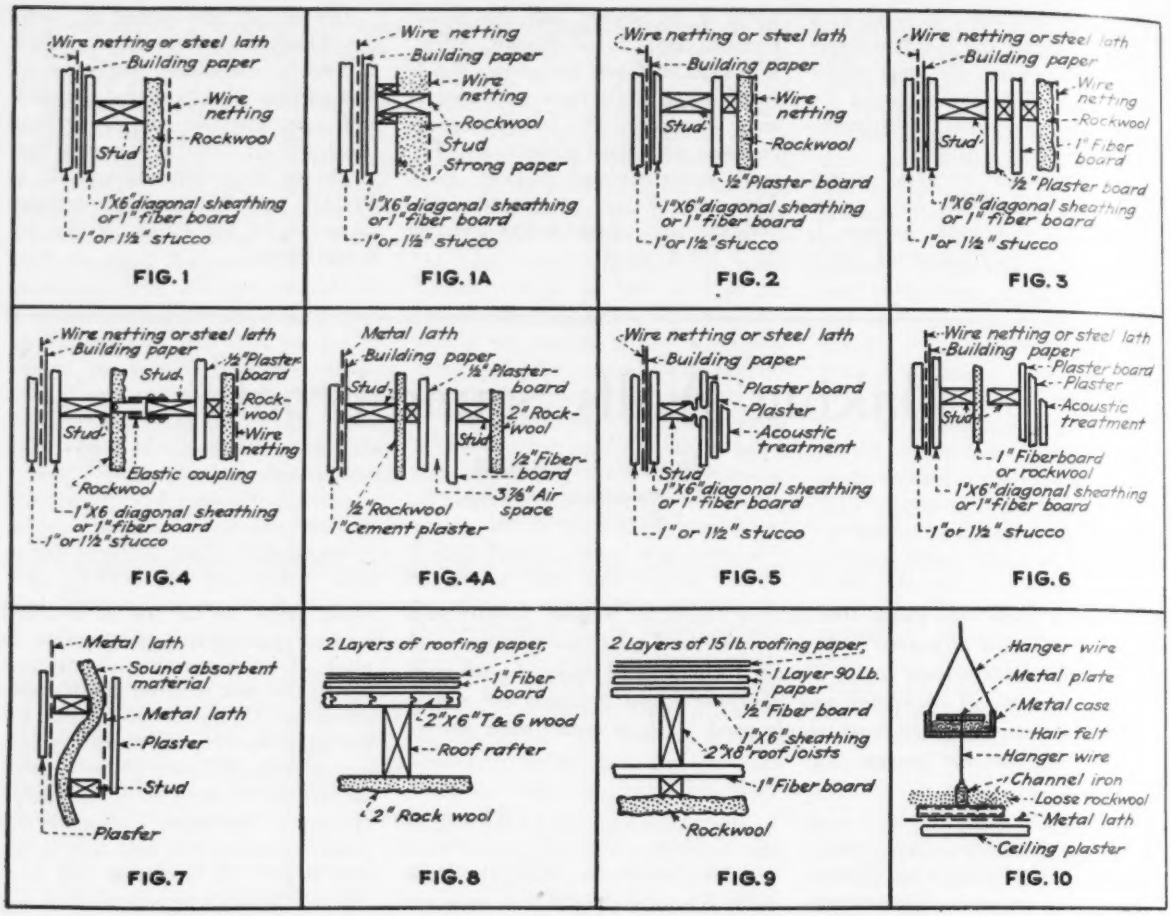
It is well known that the transmission of sound through a rigid partition occurs only to a small extent by refraction and principally by the forced vibration of the wall; that is, by the motion imposed on the wall by the incident sound. In general there are three factors controlling the movement of a wall—its stiffness, mass and resistance. The first controls mainly the amount of low frequency sound transmitted, while the second determines chiefly the high frequency transmission loss. The transmission loss of a homogeneous partition varies approximately as the logarithm of the mass of the wall per unit area.

In the case of thin flexible panels other controlling factors may enter in the transmission of sound, such as the type of elastic coupling between the sheets, the spacing of the panels, the internal damping, the manner of clamping, etc., although here again the predominant control of transmission of the higher frequencies is a matter of mass reactance. It is only in the case of porous materials, where insulation is accomplished principally by the viscous losses within the capillary pores, that mass reactance is no longer the chief controlling factor; however, such materials occupy a minor role in the sound-insulative types of construction, being notoriously inefficient as insulators unless extremely thick.

The problem of obtaining ample sound-insulation for motion picture sound stages by the use of so-called stud or wood-frame construction in place of brick masonry or concrete has in the past received considerable attention. The principal reason for the adoption of such construction is undoubtedly its lesser price or, what amounts to the same thing, the greater amount of insulation obtainable per square foot building cost after a certain degree of insulation has been reached. This is true because doubling the thickness of a solid homogeneous construction means only about 4¼ db. higher transmission loss, while the judicious doubling of a combination wall secures a considerably greater increase in insulation.

In its simplest form a stage stud wall may consist of 2x6-in. studs braced on the outside with 1x6-in. diagonal and continuous sheathing or 1-in. heavy-density fiberboard carrying the conventional building paper and wire netting to hold the stucco. The interior acoustic treatment may employ either a rockwool blanket nailed directly to the face of the studs, or rockwool packed between the studs to a varying thickness by providing a paper backing tacked to strips running the length of the studs (see Figs. 1 and 1A). Such a wall has a transmission loss at 512 cycles of from 39 to 43 db. depending on the thickness of the plaster coating (1 or 1½ in.) and the amount of rockwool (1 to 6 in.). A construction of this type is justified only in a region having a comparatively low noise level.

When occasional noise levels exceeding 65 db. exist, an inner sheath-



Typical types of framed wall construction for efficient soundproofing of radio studios and movie production stages.

ing of ½-in. plasterboard against the studs is warranted. Strips of 2x2's are then applied to the plasterboard and a rockwool blanket is nailed to the strips and, as always, protected by wire netting extending to a height of at least 12 in. from the floor. The vertical joints of the plasterboard should be coincident with the studs while horizontal joints should be backed by "fire-stops" or 2x4-in. braces to avoid any apertures leading to the space between the studs (see Fig. 2). A stage so constructed and provided with sturdy double-doors at all openings leading into the stage is located some 200 ft. from LaBrea Ave. in Hollywood and provides ample protection against practically all traffic noises on this main street, excepting perhaps fire engines. Transmission loss measurements for such a wall employing a 2-in. rockwool blanket, gave the following results:

Frequency	Transmission Loss (db)
128	35.9
256	40.1
512	45.5
1024	49.2
2048	53.7

The average transmission loss for the range 256-2,048 cycles thus comes to 47.1 db.

A still more insulative wall of the single stud type of construction is the same as Fig. 2 but employing an additional 1-in. fiberboard as shown in Fig. 3. A desirable condition provided by this construction consists in the fact that the material behind the rockwool blanket is also somewhat sound-absorbent so that smaller thickness of blanket is required in the wall.

Double studs gaining

A single stud wall construction, even of the last-mentioned type, is no assurance against heavy city traffic and loud external noises such as riveting, motor-generator sets, etc. The use of double stud walls is therefore constantly gaining ground. In such construction the interior set of studs should be tied to the outside studs by means of isolating couplings such as are now on the market in various types and sizes. Omission of such coupling may practically frustrate the desired result of high transmission loss. Fig. 4 shows how a single stud wall has been converted to the double stud type.

Fig. 4A shows details of a double stud construction for a motion picture stage wall having a comparatively high degree of insulation. (*ENR*, Aug. 1938, p. 211). It is employed in five stages recently built in Culver City, Calif., and was designed to cope with constant noise levels up to 72 db.

Radio studios

In the case of radio studios it is usually required that the acoustic treatment of the room be attractive, easily cleaned, and permit decoration by means of paints or dyes. Hence some type of acoustic tile or acoustic plaster, fireproof and washable, represents the preferred interior wall material, and a construction must be adopted which will provide a solid backing for the tile, such as plaster or plasterboard.

An illustrative way of looking at a stud wall carrying a layer of stucco

on one side and a layer of plaster on the other is to consider the stucco as a massive diaphragm fastened rigidly at intervals against the vertical studs. The vibration of this "drum-skin" is truly lessened by the stiffening timber, but because the latter is a part of the former, the vibration is directly transmitted to the plaster on the other side of the studs. The situation is altogether different in the space between the studs, however. The air in this space is likewise a medium of transmission, but a very ineffective one. The major requirement for effective sound insulation, therefore, is to provide a discontinuity between outer and inner wall at the studs.

Isolator clips effective

The introduction of a strip of fiberboard either between stud and stucco lath or stud and plaster lath is of little effect, as it represents merely an extended contact between the two. Hence the two most effective means of providing a sufficiently insulative wall is by means of a double stud type of construction or by employing so-called flexible wall isolator clips which are fastened to the studs and support the plasterboard or lath elastically at some distance from the studs (see Fig. 5). Either type is essentially a double partition providing relatively high insulation at reasonable cost and without a great deal of dead weight.

The double stud type of wall construction can be made to show a higher transmission loss by inserting between the studs a sound-absorptive material, such as rockwool or balsam wool quilt or a sheet of fiberboard (see Fig. 6). Rigid or even semi-rigid bridging consisting of a fill of pumice, cinder, etc., may sometimes seriously reduce the overall insulation of such a partition.

Staggered stud

Fig. 7 shows a so-called staggered stud type of partition employing a sound-absorptive quilt between the two rows of studs. It should be remembered that such a partition without fire-stops is classified as a non-bearing partition and cannot be used as an outside wall structure. An average transmission loss of 50 db. may be realized with such a partition employing plaster against fiberboard on both sides of the studs and by installing an absorptive blanket between the studs.

To what extent a sound-absorptive material between two plastered walls may be effective in increasing the transmission of a wall is well illustrated by a recent test made at the Bureau of Standards, in which the average transmission loss was increased from 37.5 to 45.3 db. by the insertion of rockwool between the studs.

Where there is no intervening space between the ceiling and the roof of the stage or studio it is advisable to apply a sound-insulating treatment to the roof to reduce rain noise. To eliminate the noise of airplanes flying but a few hundred feet above the stage would call for a construction similar to the enclosure walls, and may demand special considerations to comply with existing building ordinances. Fig. 8 shows a roof construction, used to satisfaction on some motion picture sound stages, which has a transmission loss which amounts to 30 db.

Fig. 9 shows roof construction as used on several stages at the Warner Bros. First National Studios. Again, the noise of the rain as it strikes the roof is not transmitted to the stage in a degree that can be recorded by a microphone.

Fig. 10 shows one of several possible ceiling isolation devices as used in broadcast studios for suspending a plastered ceiling. To reduce footfalls from the floor above to as high a degree as possible, rockwool or some other loose and sound-absorbent material is often placed above the metal lath (or plasterboard).

Notes on absorption

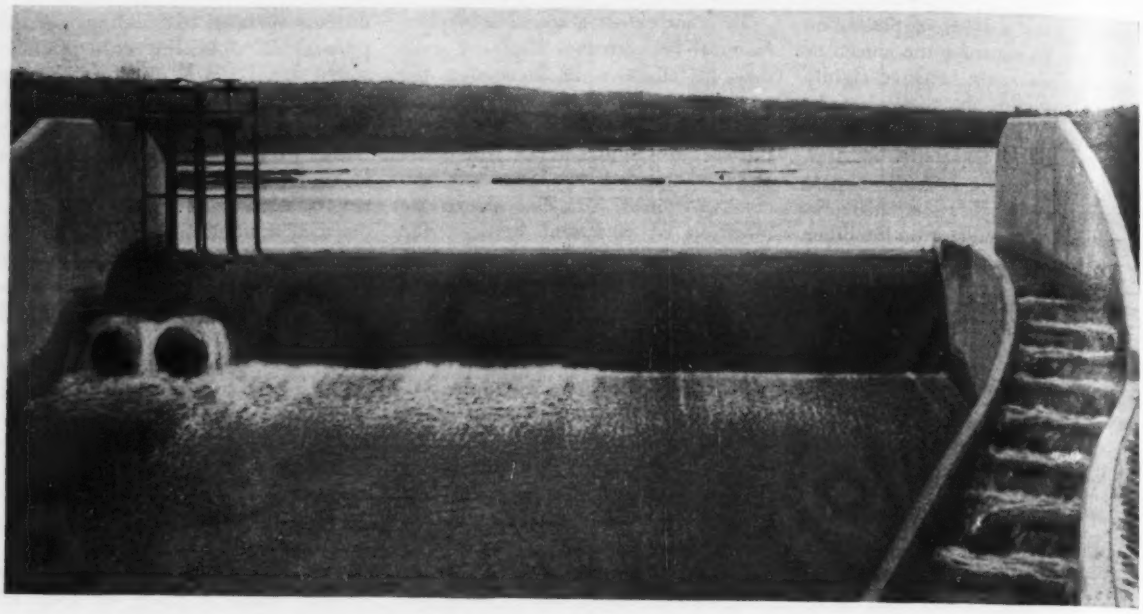
Sound-proofing includes in addition to insulation from exterior noises, means for absorbing or controlling reverberations within the room itself. A long reverberation time causes an overlapping of successive spoken syllables in a room, resulting in a marked loss of intelligibility. Too low a value of reverberation, on the other hand, lacks apparent volume and requires much more power from the speaker. The optimal value of reverberation time for various sizes of rooms has been determined by a compilation of data on various auditoriums of reputedly good acoustics, and an acoustic treatment can be selected in advance of construction which will provide a satisfactory reverberation characteristic.

Acoustical materials applied to the interior surfaces of buildings for the purpose of controlling absorption of sound are, broadly speaking, of two types—tiles and plasters. While tiles, factory-made, possess the noteworthy merits of uniform porosity, uniform strength, and "fool-proofness," acoustical plasters very often are less expensive in addition to having the advantage of being able to appear as a continuous or monolithic surface after having been applied to the acoustical walls.

As regards acoustical plasters, the following features should be considered: Many plasters, in order to obtain great absorptivity, are made highly porous by means of a gas-generating ingredient. If used in too large a proportion this ingredient may cause the plaster to dust off at the slightest touch or, if put on the ceiling, make it likely to drop off entirely when a moderately strong compressional vibration travels through the building. This point is the more important as it is difficult to patch a wall treated with an acoustical plaster so that the patch will not be visible.

Acoustical tiles

Acoustical tiles may be considered to be of two types—flexible and inflexible. Flexible tiles, which comprise such materials as hair felt, eelgrass, rubber, cork, etc., owe their absorbing power to the conversion of sound energy into mechanical energy by flexural yielding as well as to the conversion of sound energy into heat through the frictional resistance offered by the interconnecting pores or channels within the material. Inflexible tiles, which mainly include porous products of a ceramic nature, absorb largely through the above-mentioned conversion of sound energy into heat by friction, the absorption caused by flexural yielding being negligibly small unless the tile is very thin and mounted so as to introduce an air-space between the tile and the backing wall. One noteworthy merit of tile is that, being cast in a factory under controlled conditions, their porosity and hence their absorptivity, can be made alike, a feature which is not always easy to duplicate in a plaster that has to be mixed and made at the place of installation. Moreover, tiles usually have a higher absorption coefficient and a greater structural strength than plaster materials have.



SPILLWAY OF THE CRANSTON POND DAM SHOWING THE FISH LADDER BUILT ON THE SPILLWAY WALL.

A Small Dam for a Big Job

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Contents in Brief — Design and construction of a small dam calls for a lot of engineering. This article, describing the 45-acre Cranston Pond project in Rhode Island, gives the step-by-step procedure in applying basic data and sound construction practice to the installation of an earthfill, concrete spillway structure. An extra feature is the inclusion of a fish ladder.

BUILT TO SERVE TWO PURPOSES—water storage for timber and eventually to provide recreational facilities—a reservoir created with the aid of a small dam has been completed in Rhode Island. The design and construction of the earthfill dam and concrete spillway included a number of features, the description of which may be helpful to others faced with the problem of building a small structure embodying modern practice. Of special interest are the flashboard design, the transition of spillway opening from 45 ft. to 20 ft. under a bridge, and the inclusion of a fish ladder.

The dam was built in 1939 by the Soil Conservation Service of the U. S. Department of Agriculture, in connection with its sub-marginal land utilization program, and in cooperation with the Work Projects Administration of Rhode Island. The event which led to the construction of the dam was the hurricane of September, 1938, which blew down a large amount of merchantable timber and created the necessity for storage facilities in order to save this timber.

An earth dam with a small masonry and timber spillway occupied a desirable storage site on Target Brook in Cranston Township and it was at first proposed to utilize this pond and dam. However, since both the dam and spillway showed indications of partial failure, a hazard would be created if this pond were filled with logs and possible subsequent failure caused the movement of the logs downstream.

To reinforce the old structure to such an extent that it would be safe was too costly and it was decided to build a new structure. Further, the state of Rhode Island, which will administer this property, expressed a desire for a permanent dam which would form a lake suitable for wild life purposes and which might serve as the nucleus for development of a recreational area.

Drainage area characteristics

The information on which the spillway design was based included the following:

1. Size: 7 sq. miles or 4,480 acres
2. Length of principal channel: 2.5 miles
3. Difference in elevation between headwaters and outlet: 230 ft.
4. Fall of principal channel in ft. per thousand: 1.74 ft.
5. Approximate average width of the basin: 1.480 ft.
6. Soil texture: gravel, glacial deposit
7. Type vegetation:
   50 per cent 2nd growth timber
   10 per cent swamp
   40 per cent pasture
8. Character of topography: Slope 0 to 10 per cent.
9. Area of reservoir at spillway level: 45 acres
10. Storage capacity at spillway level: 135 acre-ft.

After evaluating the various watershed and channel factors and considering the effect of temporary spillway storage on maximum flood reduction it was estimated that a spillway discharge capacity of at least 1,970 cfs should be provided. It is realized that a severe rainstorm over the watershed may cause a higher reservoir outflow, but the economy of providing a larger concrete spillway was questionable. The dam proper involves only a low earthfill and there is little danger of property damage or loss of life downstream in the event of failure. As an alternative, the earthfill at the end of the structure opposite the concrete spillway was depressed for a distance of 80 ft. In case of overtopping, as a result of unprecedented storms, this emergency plug would function and only a small section of the fill would be damaged.

The standard weir formula $Q = CLH^{3/2}$ was used in determining the necessary spillway length. According to Horton, a coefficient of about 3.83 should be used for the proposed weir section with a 5-ft. head. A spillway length of 45 ft. was provided.

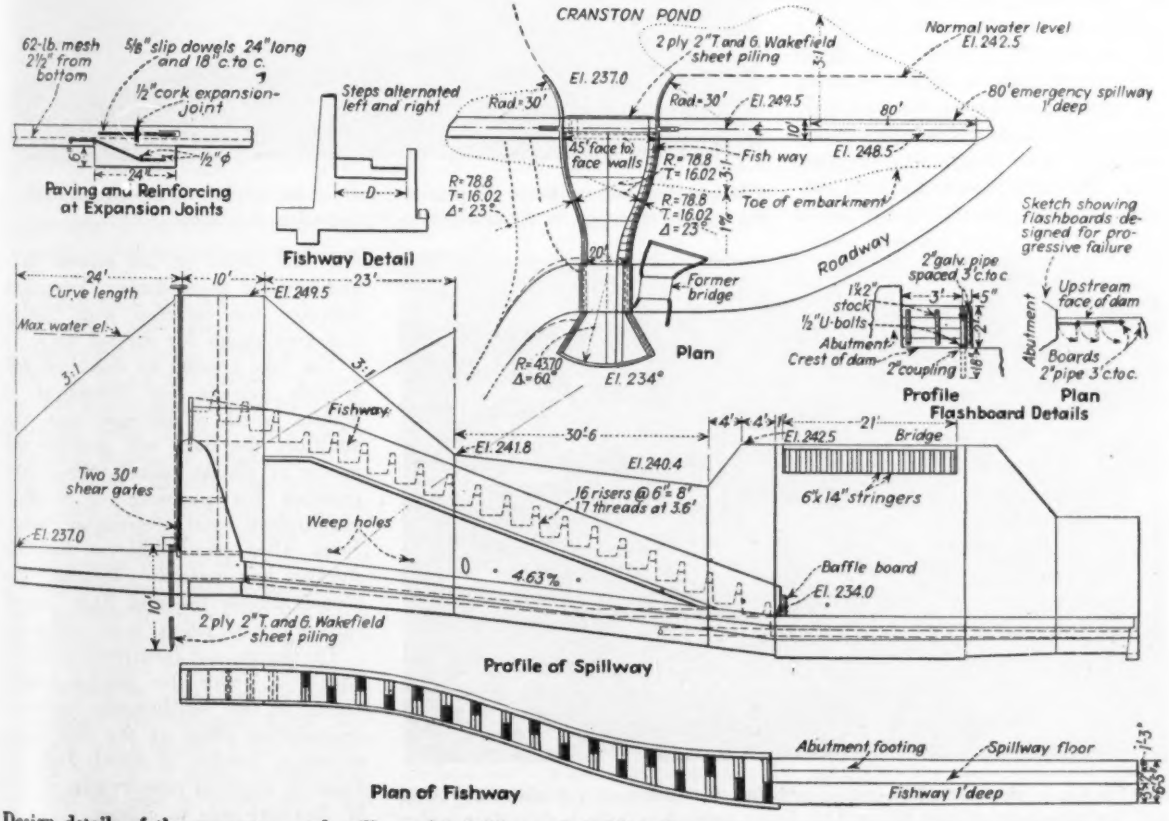
Because of favorable foundation conditions relative to economy and simplicity of construction, the spillway was located in the west bank of the stream. It was designed as a modified trapezoidal gravity section with parabolic crest. A standard design for the earthfill section was adopted having a top width of 10 ft. and slopes of 3 to 1 upstream and 2 to 1 downstream. A double row of 2-in. timber piling was driven to prevent piping through or under the entire structure.

The two principal factors involved in the design of the completed structure were: that the location of the spillway made it possible to raise the base of the gravity section to an elevation considerably above the old stream channel, and the continued use of the old dam as a road made it necessary to build a substantial bridge through which the discharge of the spillway must be controlled in order to protect the bridge abutments. It was also desirable to constrict the flow under the bridge as much as possible in order to reduce its length and simplify construction.

The spillway below the gravity section was paved, and walls constructed to control the flow and to effect the transition between the 45-ft. spillway opening and the 20-ft. bridge opening. This construction was possible because of increased velocity due to the grade between the base of the gravity section and the original streambed elevation. The T-type design was adopted for spillway walls. Bridge abutments are continuations of spillway walls with the section enlarged due to increased height and bridge loading.

Construction features

All walls and abutments are designed with foundation footings to take the spillway channel floor slabs on a 6-in. step, and are reinforced throughout with round steel bars. Expansion joints were provided at each end of the 30-ft. section between the dam and the bridge, as well as along the base of the walls for the floor slabs. All vertical expansion joints were of the keyed type, filled with heavy felt and bituminous paint. All expansion joints in the floor slab system were of the slip dowel type with pressed cork filler. Construction joints were of the keyed type, heavily coated with bitumin-



Design details of the concrete paved spillway, fish ladder, and flashboards.

ous paint on the adjoining faces.

The floor slabs were of 6-in. concrete reinforced with heavy steel wire mesh and having under-slung joints in both directions. Instead of using weep holes in these slabs to relieve any hydrostatic pressure from below which might cause uplift or displacement, two lines of tile underdrains were installed with the discharge ends coming to the surface of the slab at the north end of the bridge.

At the request of Rhode Island conservation officials a fish ladder was designed and constructed in connection with the dam. This ladder, built adjacent to the east wall of the spillway, consisted of 16 risers and 17 treads arranged so that fish could go over the dam in easy stages. Each riser provides a jump of 6 in., and alternate sides of risers are cut away to create a swirling action in the descending water. The combined treads and risers provide pools where the fish may rest during the ascent. A removable baffle was installed at the lower end of the spillway to guide fish during low water stages.

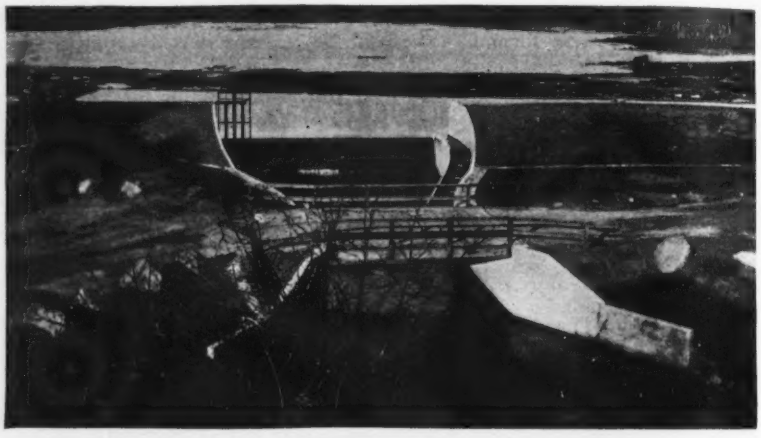
Flashboard failure design

Another feature of the dam is the provision for flashboards. The present depth of the lake is sufficient for log storage; however, increased water depth may be desirable when the lake is used for recreational purposes. The flashboards adopted are designed for progressive failure. They are constructed in 3-ft. sections, each of which swings on a pin that turns in a pipe embedded in the gravity section of the spillway. The flashboards may be opened manually by removing the pin that secures the section at the west end of the dam, or they may be opened automatically as the elevation of the lake approaches the top of the dam. Provision is made for this by designing a pin—inserted in the west spillway wall against which the end flashboard acts—which will shear when the head over the spillway crest approaches 6 ft., thus allowing each successive section of the flashboard to swing free.

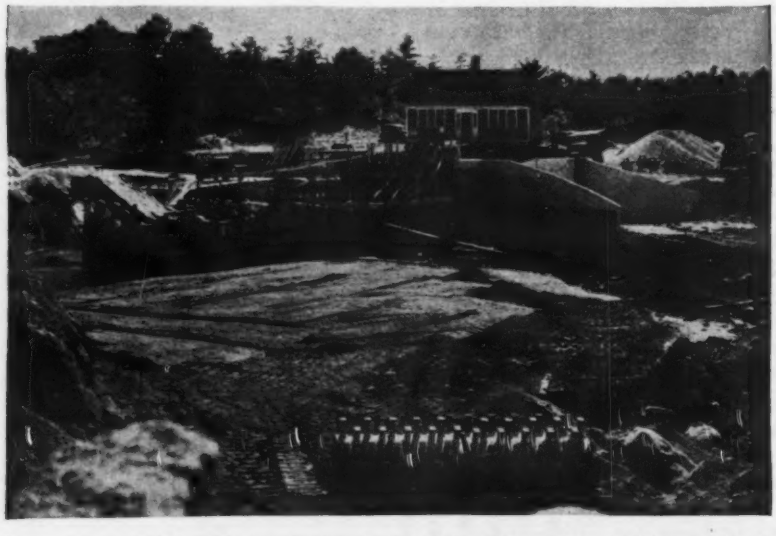
Provision was made for lowering the pond elevation by the installation of two 30-in. pipes through the dam. These pipes use manually operated shear-type gates.

In order to prevent loss of logs through the spillway, and to prevent damage to the fill, a log boom was installed upstream from the spillway. Large logs were secured by heavy chains to glacial boulders present in the lake bed.

The best recognized construction practices were followed in building this dam. Foundations were excavated to firm material, all muck and vegetal matter being removed from the foundation of the earthfill. Earth having a fairly high clay content was used for the fill. This was placed in 9-in. layers and compacted with a sheepsfoot roller. The spillway was completed first and streamflow diverted through the pipes in the dam during construction of the fill. Well-mixed 1-2-4 concrete, amply reinforced, was used throughout. Concrete walls were cured by leaving wall forms on for several days and keeping them damp. Pavement concrete was covered with burlap and kept damp for several days.



Finished dam and spillway, showing the start of log storage in the reservoir. Note the transition section in the spillway to accommodate the bridge.



Construction of the earth dam section included the driving of a double cutoff wall, and the placement of clay fill in 9-in. layers compacted with a sheepsfoot roller.

The lake created by this dam will provide storage for thousands of dollars' worth of salvaged logs. In addition, the dam will provide the people of Rhode Island with a lake valuable for purposes of wildlife propagation and recreation many years after its usefulness for log storage has passed. Because the area is largely forested, little loss of capacity will result from siltation.

The design and construction of this dam was under the general supervision of the Northeastern regional engineering office of the Soil Conservation Service of which John P. Jones is regional conservator. Ralph M. Beaudry was in charge.

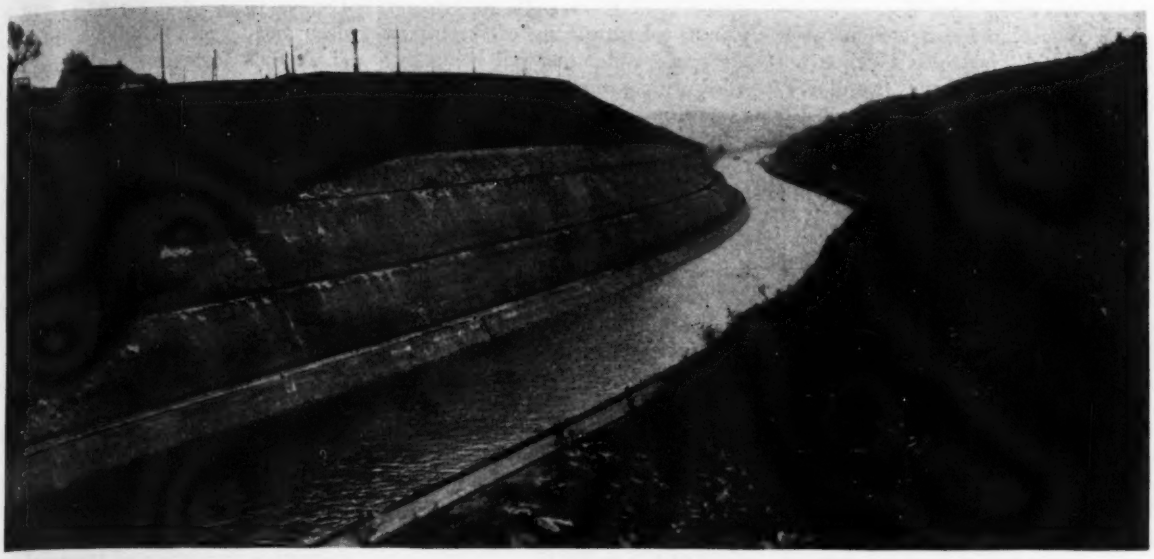


FIG. 1. BELGIUM'S ALBERT CANAL AT THE DEEP PART OF THE VROENHOVEN CUT IN SOFT GROUND.

War Christens Belgium's Albert Canal

Contents in Brief—Ten years of peacetime construction, a colorful dedication by King Leopold last summer, and now a defense barrier in what is being called the greatest battle ever waged—so goes the rapidly developing story of Belgium's great Albert Canal. Built both as a line of defense and as a traffic canal that can carry 2,600-ton barges from Liege to Antwerp, its war function gets first trial. But either for peace or war, its design and construction command interest and respect. Deep cuts, heavy embankment, high retaining walls and six locks that overcome 184-ft. difference in level are features that make it one of the notable canal accomplishments of the world.

AN UNUSUAL COMBINATION of commercial and military purposes is served by the 80-mile Albert Canal, in Belgium, which was opened to traffic in 1939 and accommodates barges up to 2,600 tons capacity. It connects the great seaport of Antwerp, on the river Scheldt (and 50 miles from the sea), with the inland port of Liege, on the River Meuse, as shown in Fig. 2. This latter port is at the head of a system of railways and inland navigation serving an industrial and coal-mining district that extends some 100 miles westward along the Meuse valley. Formerly, the only waterway communication between Liege and Antwerp was a 98-mile route by small canals having 23 locks. General features of the new waterway are listed in the accompanying table.

The military importance of the new canal has been amply demonstrated in the happenings of the past weeks. Where the canal is carried on embankment, one bank is built higher so as to command the other, the outer face of which has a long flat slope towards the frontier.

Construction was begun in May, 1930, and was practically completed in June, 1939, when the collapse by sliding of one of the embankments necessitated postponing the opening of the canal until September (*ENR*, July 14, 1939, p. 46). The heaviest works are on the upper or eastern portion of the canal. Besides deep cuts in rock and wet soil, and large embankments which carry the canal high above the level of the surrounding country, there are six sets of locks, a flood gate, a concrete river siphon and numerous smaller siphons, some of which were precast and floated into place in dredged trenches. Quays, both public and private, extend along the Meuse for several miles at Liege, and are provided at intermediate points, and there is a large number of bridges for railways and highways, as noted later.

The canal is lighted throughout to permit of ready navigation at night.

Wall and embankment sections

Structurally the canal is notable chiefly for certain sections between retaining walls and heavy embankments and for two deep cuts, one in rock and one in unstable earth. In general where the canal is between masonry retaining walls its minimum width is 116 ft. at the water surface and 82 ft. at the bottom, but for a great portion of its length it has a width of 300 ft. or more, providing ample reservoir capacity for locking operations. Curves have a minimum radius of 4,000 ft. and are widened considerably. Two of the largest barges used (328 x 40 ft.) can pass at any point. The minimum depth is 16½ ft. along the center line.

From its entrance at Monsin, on the River Meuse, the canal is between masonry walls for some distance, beyond which it is partly an enlargement of an old canal, in cut and fill. Here the compacted bottom was retained, new banks being built to give the increased cross-section and to raise the water level about 9 ft. This work was carried on without interfering with traffic. As the new water level is 7 to 20 ft. above the ground level, the banks are made very large with a a width of 33 ft. at the top and 65 to 100 ft. at the base. The inner slopes are faced with a watertight course 5 ft. thick, composed of 40 per cent clay and 60 per cent gravel. Here the minimum width is 230 ft. at the water surface and 130 ft. at the bed, with a depth of 16½ ft., but at places the canal widens to 330 ft. A top slope of 6 to 4 extends to a 6½-ft. berm at 3½ ft. below the water level, a slope of 10 to 4 then continuing to the bottom. From the berm to 2 ft. above water the slopes have stone paving on a concrete base, above which they are faced with turf.

At Wandre, where the canal is confined between the river and a group of factory buildings, it has concrete retaining walls giving a width of 148 ft. at the surface and 82 ft. on the bed. And space restrictions further on necessitated the construction of a wall along one side for about a mile. Foundation conditions led to the construction of these walls on concrete piles faced with a line of sheetpiling, the space under the wall being then filled with cement grout. Watertight expansion joints are spaced 65 to 100 ft. apart. At Haccourt, a lock for 600-ton barges connects the canal with the canalized River Meuse, the level of which is 24 ft. below that of the canal.

Beyond Lixhe, an old canal is again followed, but as the new water level is 33 ft. above the surrounding country the new embankments were made of great width, 600 to 800 ft. at the base, with a 33-ft. towing path at the top, which is 6 ft. above the water line. A watertight core, built with its base in a trench 6 ft. deep, is composed of a mixture of clay and gravel, 40 and 60 per cent, respectively. In this part of the work the canal has a width of 175 to 206 ft.

These banks have long outer slopes which are dressed with soil and turfed, so that they can be used for farming purposes. On the inner slopes, 5 to 4, the watertight facing course is covered with an 8-in layer of gravel as a base for 12-in. concrete slabs 20 ft. long. The slabs foot against a horizontal concrete beam supported on concrete piles with a line of sheetpiling 13 ft. deep. A concrete beam also encloses the tops of the slabs.

Deep cut sections

Beyond Lanaye, Fig. 2, the canal enters a series of cut sections. Nearest Lanaye is an open cut 65 to 212 ft. deep and largely through a tufa and chalk rock formation which hardens on exposure and erodes only on the surface. Steam shovels removed the clay and gravel overburden, and also the rock after it had been broken up by liquid-air cartridges. Pneumatic tools dressed the slopes, which are nearly vertical and are broken by berms of 3 to 6-ft. width at vertical intervals of 33 ft. Beyond this rock cut (Fig. 3) the River Geer is carried under the canal by a reinforced-concrete siphon having four culverts or channels 9 x 8½ ft.

A ridge, Fig. 1, rising 100 ft. above the level of the canal had to be crossed beyond Briegden and was a serious obstacle, as borings to a depth of 130 ft. showed a treacherous formation consisting of layers of wet clay and sand. To avoid such a deep cut, 3½ miles long, with its possibility of slides, by introducing a summit level, would have involved additional locks and large pumping equipment to maintain the water level. In view of the disadvantages of this alternative, it was decided to follow the original plan for the deep cut. The slopes were specified at 4 to 1, to reduce the danger of erosion and also to minimize the danger of slides by reducing the load on the subsoil.

Since the clay is found to dry and disintegrate when exposed to the sun and then softens and swells if wetted by rain, it was required that the clay surface should be covered promptly by a 3-ft. layer of clean gravel and sand. This layer, like the rest of the slopes, was covered finally with soil and turf. A section of this cut is shown in Fig. 4. To lower the groundwater level below the canal bed and so prevent upward pressure, drainage was provided by oval perforated concrete pipes laid in trenches filled with sand and gravel carefully selected and graded to serve as a filter. The filtering surface was made sufficiently large to insure that the velocity of flow will be below that at which soil particles will be moved. The sides and bottom of the canal, for about two miles, are lined with 30 in. of concrete reinforced by sheets of expanded metal.

Excavation of the wet soil was handled by scrapers and crawler tractors, as the ground would not carry the heavy excavation machinery used elsewhere on the canal. Belt conveyors loaded the material into dump

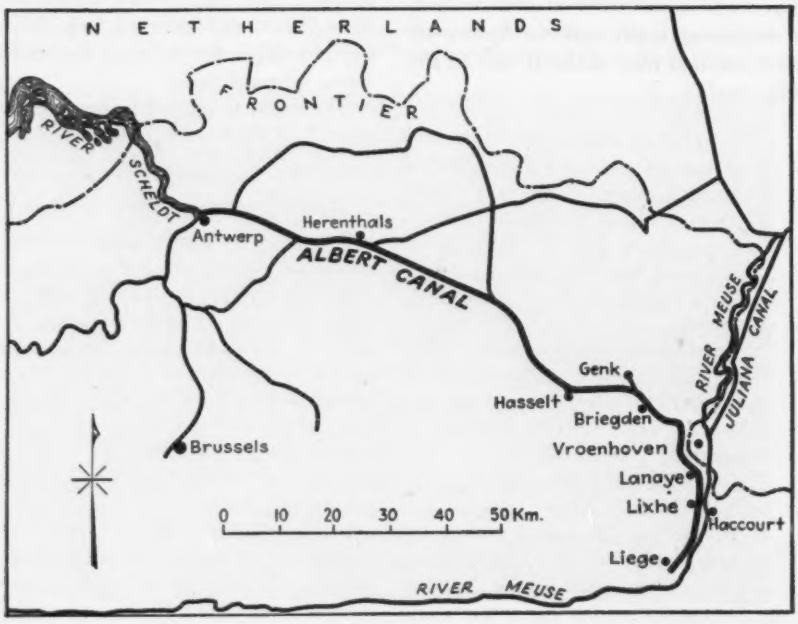


Fig. 2. Albert Canal provides a sea route for 2,600-ton barges from Liege to the seaport of Antwerp in Belgium.

wagons. In spite of this, the scrapers, tractors and wagons were frequently bogged, and work had to be halted until the ground dried out. No work could be done in wet weather. In the more solid underlying soil, steam shovels were used, and the canal section was excavated by dragline machines. By means of the drainage system and a pumping plant the water level was kept below the bottom of the excavation at all stages of the work, and the cut was finished without accident.

In the two short reaches beyond the locks at Genk (Fig. 2) the width of the canal is from 250 to 300 ft., to increase the volume of water stored. Otherwise, the loss of water by frequent locking might seriously affect the water level or cause undesirable turbulence in the canal. It was in the first section beyond Genk that the slide occurred in June, 1939. According to the official report, the failure was due primarily to gradual saturation of the extremely fine sandy soil used, which tends to slip when wet. To prevent further trouble, all embankments made with this material were reinforced with a covering of pervious sand and gravel and protected by drainage works to prevent saturation.

Beyond Hasselt, the canal is partly in new ground and partly follows sections of old small canals. At Antwerp, the canal enters the Strasburg Dock by a widened section which is practically an extension of the dock, since it provides facilities for mooring, loading and unloading vessels. This port is of the closed type, with lock entrance from the river, so that the water level in all the docks is maintained at 13 ft. above sea level, regardless of tidal or other changes in the river. With the new canal entrance from the land side, considerable changes had to be made to the adjacent land routes.

Fig. 3. A deep rock cut near Lanaye was one of the heaviest excavation operations in the canal work.

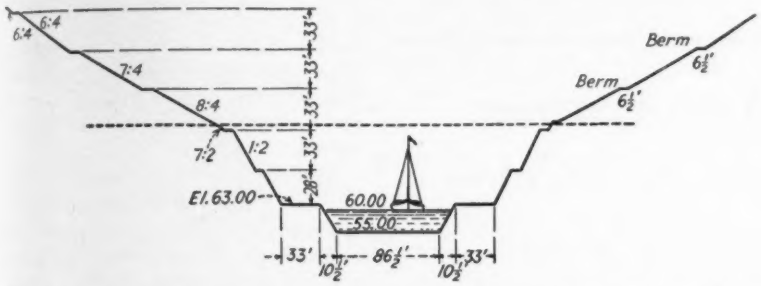


Fig. 4. Deep section of earth cut a shallower part of which is shown by Fig. 1.

Triple locks provided

There are six sets of locks on the Albert Canal, with a total drop of 184 ft. from the River Meuse to the Antwerp docks (or 197 ft. to sea level), as shown by Fig. 2 and the accompanying table. The canal leaves the Meuse at Monsin, where a river-control dam with roller gates maintains the river and the first reach of the canal at El. 196.8. Beside the entrance lock there is a channel 53 ft. wide with flood gates. This channel is used normally for navigation, being closed only when a high flood level in the river might endanger the canal. At such times vessels will use the lock. At the head of each reach of the canal there is a group of three locks. Twin locks 446 x 53 ft. provide for the larger vessels and for barges in tows, while a lock 181 x 40 ft. serves for quicker locking of smaller craft and reduces the amount of water used in locking.

At five of the locks the drops were made practically equal, in order to balance the feedwater supply among the several reaches. These reaches were also made as long as possible, to minimize the lowering of water level due to frequent lockings. Topographical conditions, however, necessitated two short reaches between Genk and Hasselt, and in these cases the lowering due to frequent lockings is reduced by enlarging the cross-section of the canal to provide ample reservoir capacity.

In the concrete construction of the locks there is no lining of metal or special concrete mix for the conduits, for although the rate of flow is rather high, 10 ft. per second, the water does not contain any abrasive matter, and experience at other locks indicates that there will be no trouble from erosion. One large lock can be filled or emptied in seven to eight minutes. Cross culverts connect the twin locks. A longitudinal bypass culvert, with roller sluice gate, connects the

ESSENTIAL NAVIGATION FEATURES OF THE ALBERT CANAL OPENED IN 1939 BETWEEN LIEGE AND ANTWERP, BELGIUM.

Reaches and Lock Shifts

	Elevation above Sea	Fall ft.	Distance miles
River Meuse at Liege	196.80	.....	.....
Monsin, entrance	196.80	.....	1.24
Genk lock	196.80–163.67	33.13	24.43
Diepenbeek lock	163.37–130.54	33.13	2.64
Hasselt lock	130.54– 97.41	33.13	2.85
Quaedmechelen lock	97.41– 64.61	32.80	16.86
Ocken lock	64.61– 31.81	32.80	11.53
Wyneghem lock	31.81– 13.11	18.70	14.81
Strasburg dock; Antwerp	13.11	.....	5.45
Lefebre dock; Antwerp	13.11	.....	0.56
Totals	.....	183.60	80.37

Old and New Routes Compared

	Albert Canal	Old Canals
Length, miles	80	98
Locks, number	6	23
Ave. speed, mph, motor barge	5.5	3.0
Ave. speed, mph, 4-barge tow	3.7	2.5
Locking time, min.; motor barge	20	30
Locking time, min.; 4-barge tow	30	100
Navigation time, hours; motor barge	16	42
Navigation time, hours; 4-barge tow	24	77
Voyage, days; motor barge	1 to 1½	4 to 6
Voyage, days; 4-barge tow	2 to 3	6 to 10

upper and lower reaches at the lock, so that if the lower reach is depleted by frequent locking it can be replenished from the upper reach, independent of the lock. Approaches to the locks are widened to form forebays 328 x 200 ft.

Steel lock gates, of welded construction, are of the double-leaf mitering type, with a height of 18 and 50 ft. for the upper and lower gates, respectively. Roller sluice gates at the bottom provide for rapid emptying in emergency. Each gate is operated by a rack and gearing. Electric power for all gates, valves and sluices is furnished from utility power plants.

Of 66 bridges which cross the canal, 56 are fixed steel spans, seven are of concrete, and three are bascule spans at Antwerp, where there was no room for inclined approaches to high-level bridges. The minimum headroom under fixed bridges is 21 ft. Most of the bridges are for highways, and have 65-ft. roadways, with 10-ft. sidewalks, but some of these have a narrow-gage track laid in the roadway as a link in Belgium's extensive system of light railways. Some 50 of the steel bridges are of the Vierendeel type, with welded connections, having a main span of 239 ft. and plate-girder spans of 109 ft. They were built at the sites and rolled longitudinally into place. One of these welded spans failed in 1938 (*ENR*, Aug. 18, 1938, p. 204) and two others failed in January, 1939, during the exceptionally cold weather that was experienced throughout Europe at that time.

Excavation for the canal amounted to 89,000,000 cu.yd., besides 22,330,000 cu.yd. for levees and bridge approaches, making a total excavation of 111,630,000 cu.yd. The total cost of the canal approximated $70,000,000, including $8,000,000 for land and right-of-way. But this latter item included extra property whose value will be increased by the canal, so that eventually it can be sold at high prices for industrial development and thus recoup for the government a part of the initial cost. This account account of the canal work is condensed from a series of articles which appeared in *Engineering* of London, England.

Hog Feeding With Garbage Under Study in Los Angeles

Contents in Brief—Pasteurization and dehydration processes are being studied in a search for better methods of utilizing garbage as hog food. Possible legislative restrictions and economies of hog-feeding are factors stimulating the study at Los Angeles where sale of garbage hog food brings a revenue of $100,000.

EXPERIMENTS with garbage pasteurization and dehydration are now being made at Fontana Farms east of Los Angeles in an endeavor to improve, if possible, present methods of utilizing garbage as a hog food. Los Angeles now produces about 200,000 tons of garbage per year most of which is sold for hog food at 50 cents per ton to the Fontana Farms some 50 miles from the city (*ENR*, Aug. 6, 1925, p. 208.)

Factors that may necessitate changes in the present operating plan are: (1) possible legislation putting new restrictions on this means of garbage disposal; (2) the greatly decreased food values now found in garbage; and (3) the relatively low prices for other materials, such as grains, that can be used for hog food.

It is recognized that the economies resultant from salvaging food values and other materials from garbage vary widely with seasons and economic conditions. For example, grease and tankage by-products that brought a good price some years ago now bring such low prices as to be hardly worth salvage. In 1923, the Fontana Farms normal operation produced an average of about 60 lb. of pork per ton of garbage. Now the production has dropped to about 30 lb.—indicative of the greater economy in kitchen operation which has come with changed economic conditions.

With a view to exploring possibilities of a steam-operated pasteurization process, an experimental plant is being operated at Fontana. Chemical analysis shows that the raw and pasteurized garbage have practically the same content. The pasteurized product, however, suffers a loss of vitamins which might have a serious effect on the food value. Attention is being given to the questior of whether these could be replaced economically and if so, with what methods and materials.

Thus far, feeding tests with the pasteurized product indicate a 15 per cent decrease in pork products. Careful investigation is under way to find, if possible, whether this is caused by less vitamin content and if so how these desirable elements can be restored.

In some experiments with dehydration, as distinct from pasteurization, garbage started with a moisture content of about 70 per cent and this was reduced to 10 per cent in the finished product. Percentages higher than 10, it is found, are in danger of molding in storage and less than this percentage results in moisture absorption from the air. When ground grain is added, it is not necessary to carry the dehydration as far as otherwise. An important consideration is to avoid temperatures in the dehydrator that would char garbage and thus decrease its food value.

Cooperating with Fontana Farms in studies now under way are the agricultural department of the University of California and the State Board of Health. The city is not a major participant but is an interested party because the garbage disposal contract with the Fontana Company expires in October, 1941. Moreover, if the state legislature were to pass a bill prohibiting the feeding of garbage to hogs by reason of the trichinosis danger (such a bill was proposed last year) or if the city for any reason had to resort to incineration at a cost of say $1.50 per ton, the city's present garbage revenue of $100,000 per year (200,000 tons at 50c. per ton) might be replaced by an expense item of $300,000 per year —a net difference of $400,000 per annum in the city's budget.

WIRE ROPE *for* CONSTRUCTION

ITS MANUFACTURE · SELECTION · AND USE

AN ENGINEERING NEWS-RECORD REPORT

May 23, 1940

Wire Rope for Construction

Introduction

• Although wire rope is more widely used than almost any other single item of construction plant—in shovels, cranes, scrapers, draglines, hoists and cableways, for example—it is not generally well understood by users. This is not to be wondered at since few machine components are subjected to such severe and complex service conditions. Almost invariably the individual combination of grade, quality and construction details of a rope design is arrived at as a best compromise between the two principal requirements, ruggedness and flexibility, which are more or less conflicting, combined with other considerations arising from each special set of service conditions.

The stimulus furnished by the highly competitive character of the industry and the remarkable developments of the machines on which wire rope is employed have brought into use a large variety of ropes from which the engineer may select a type most suitable for a given application. The problems of rope engineering, as a consequence, have become quite complex and it is not surprising that wire rope engineering has developed into such a specialty that rope designs and other details of construction have become largely the responsibility of the rope manufacturer. This is as it should be. Nevertheless it is desirable that those who use rope should familiarize themselves with the constructions available as well as with the several qualities and grades of rope so that they may more intelligently submit their rope problems to the manufacturers.

It is quite possible that the wide diversity of rope designs available has, in a measure, tended to bewilder the user, and the fact that any one of them is reasonably safe has caused him to conclude that all will serve him equally well. No conclusion could be wider of the mark.

With this situation as a background Engineering News-Record decided that a start toward improvement would be made if users could be impressed with the importance to them of wise and proper selection and use of wire rope of the right construction and if the general knowledge and beliefs in the field could be set down in one place in a simple straightforward manner. This report is a result of a survey which included a 7,000-mile field trip, visits to wire rope plants and construction jobs in 30 locations and discussions with several hundred individuals, including a majority of the recognized authorities in the field.

THE ESTIMATED CAPACITY of 16 wire rope manufacturers in this country is about 200,000 tons per year. In 1939, production was about 50 per cent of capacity. Of the total an undetermined but large proportion was placed in service on construction machines.

The manufacture of wire rope goes back to ancient times, when both wires and strands were tediously fabricated by hand. Machine-drawn wire gradually came into use abroad, and close to a century ago the first American machine-made wire rope was placed on the market. Progress in metallurgy, in wire drawing, heat treatment, stranding, and closing into rope, along with the design of special wire rope constructions for particular types of service, have contributed through the years to bring about the present development of the wire rope industry. Available wire rope constructions totaling about 80, of which some 30 are in common use, have given the purchaser a wide range of selection.

What is wire rope?

Fundamentally, wire rope consists of a combination of stranded wires laid helically around a central core. The individual wires are laid into strands and the strands "closed" into rope by highly refined and rugged machinery so designed that the individual wires will be placed into their proper position in accordance with the rope engineer's design and so constructed as to realize the benefits of mass production without sacrificing a high degree of dimensional accuracy.

"Construction" of a wire rope is defined as its design, including the number of strands, number of wires per strand, arrangement of wires in each strand, direction and type of rope lay, and type of core used. Upon this construction, as well as upon the quality of material used, quality of manufacture, dimensions selected, and quality and grade of steel employed depends the suitability of a given wire rope for a particular service.

The great variety of available designs is defended by wire rope engineers on the ground that they offer the purchaser a wide opportunity for more accurate selection of rope for specific needs. This is true, although in most cases two or three dozen constructions offer sufficient range to meet the user's requirements. Most of these constructions differ materially as to flexibility, ability to resist abrasion, and capacity to withstand fatigue stresses. Choice of rope for a particular service is often a matter of compromise between characteristics, since these are bound to conflict more or less by the very nature of wire rope. One cannot have maximum strength, maximum resistance to abrasion, maximum stiffness and maximum flexibility in the same rope, which is but another way of saying that the all-purpose rope is nonexistent.

Rope lays

The basic way of characterizing a wire rope is by its "lay". In a right lay rope, the strands run from left to right across the top when passing away from the observer. In a left lay rope, from right to left. While the strands themselves may be made up in either right or left lay, the term is used only to characterize the direction in which the strands pass around the core.

When the wires in a strand are laid opposite in direction to the lay of the strands in the rope, the rope is called regular lay, and may be either right or left lay. If the wires and strands are laid in the same direction, whether right or left, the rope is called Lang lay. The type of lay exerts an important influence upon rope performance. Regu-

lar lay ropes are more common than Lang lay because they kink less readily, but Lang lay ropes have a greater wearing surface. If Lang lay ropes are preformed, the tendency to kink is minimized because in fabrication each individual wire and strand is given a "set" to the helical shape that occurs in the rope itself. This bending or set results in a relatively inert rope, so that the tendency of the wires to fly apart when cut or broken is minimized.

The development of preformed rope deserves some special mention because, in the 15 years since it was introduced, it has already come to represent nearly one-quarter of the annual production. Among the advantages claimed from the inertness above noted are an ability to resist fatigue bending, and less tendency to kink, making it easier to handle. In a preformed rope both the wires of the strands and the strands of the ropes are set to the exact helix that they assume in the finished rope. Opinion as to the advantages of preformed wire rope in different fields has not fully crystallized among either manufacturers or users; but the use of such rope is steadily increasing in a variety of services.

Types of construction

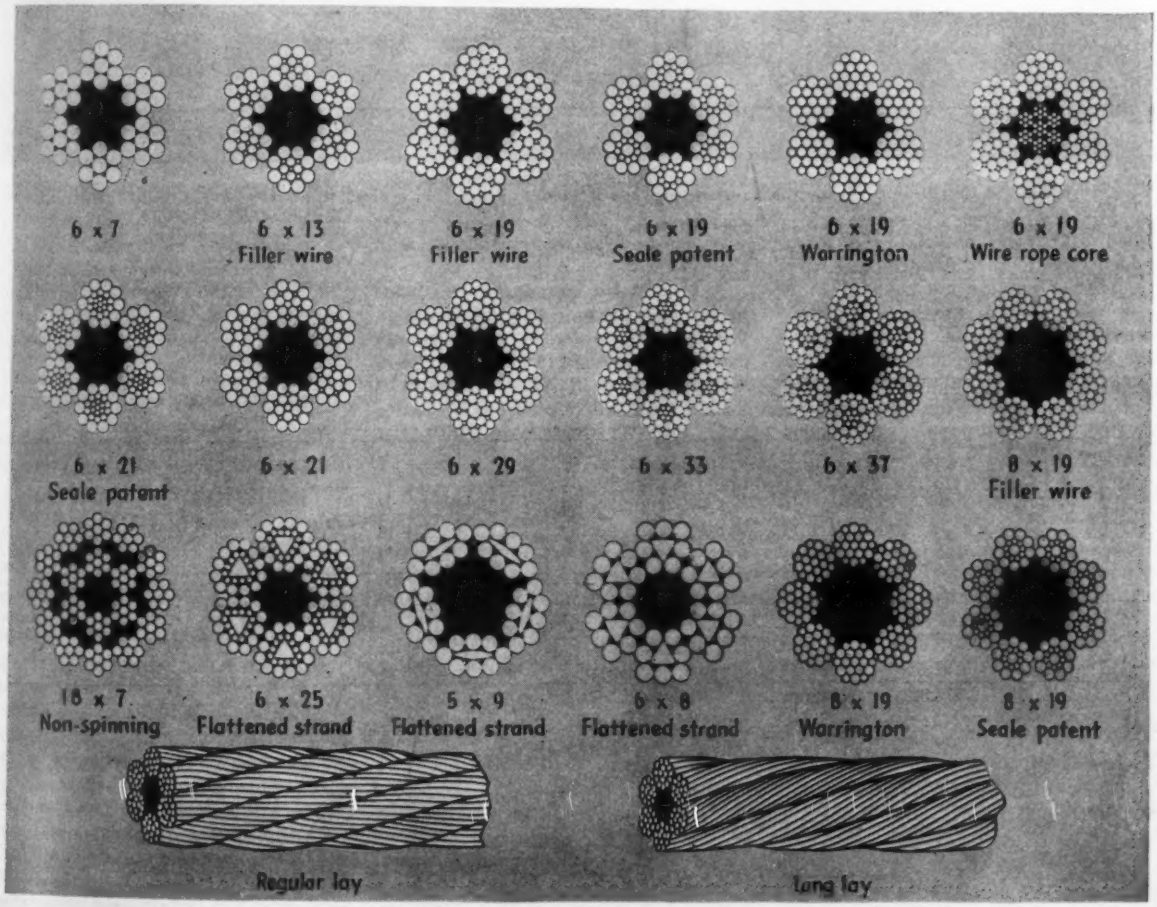
Basic wire rope constructions include:

(1) *One-sized wire.* This is a simple construction, sometimes referred to as coarse laid rope, containing the minimum number of wires, minimum flexibility and small resistance to bending stresses. A strand of this type consists of uniform diameter wires laid around a core wire of somewhat larger size. A typical rope of this type would have a non-metallic center and be designated as 6x7 construction, which means 6 strands of 7 wires each.

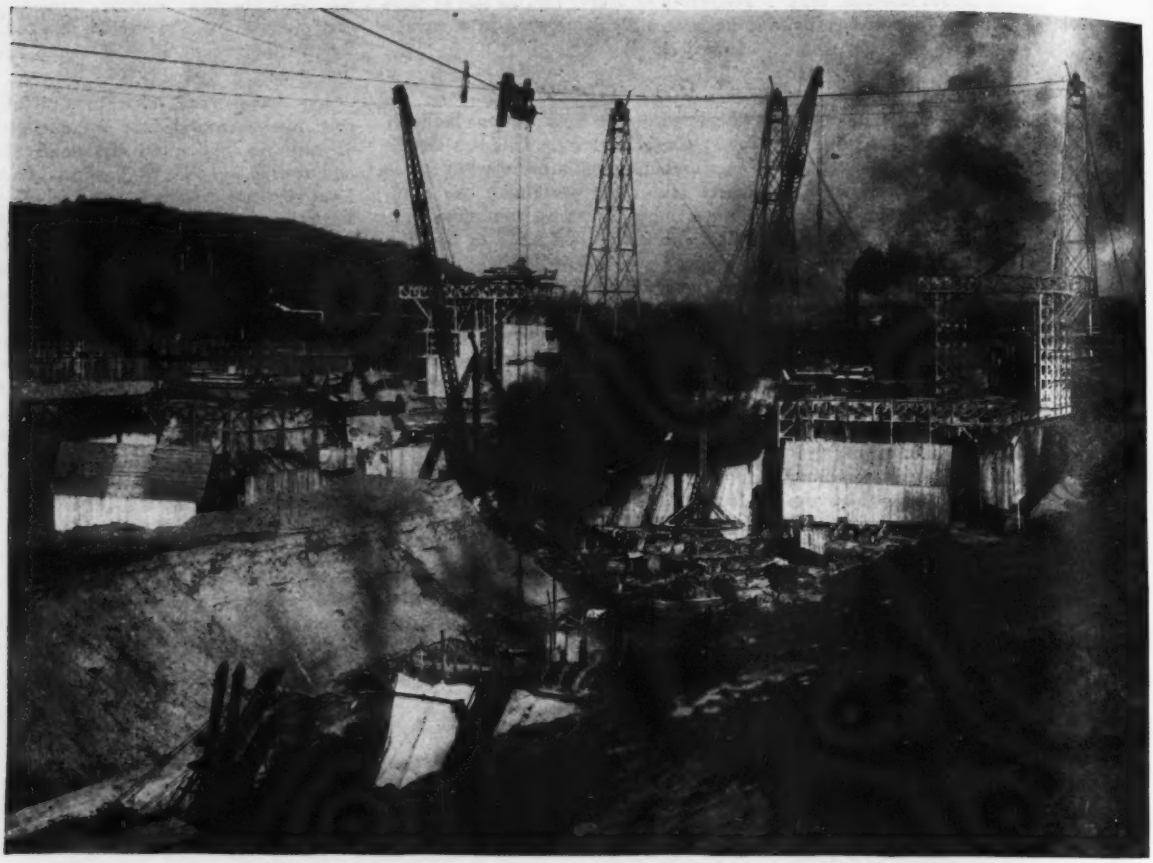
(2) *Warrington.* In this type 12 outer wires of each strand are alternately large and small and surround 7 wires of intermediate size; hence sometimes called three-size construction. It is widely used in the 6x19 and 8x19 groups. Resistance to abrasion is below that in the 6x7 and 6x8 groups on account of the increased number of outer wires in the Warrington strand. Ability to withstand bending stresses is characteristic of Warrington, due to the larger number of smaller wires used per strand.

(3) *Seale.* This type consists of a core wire surrounded by 9 inner wires of uniform but relatively small size, and on the outside, by 9 wires of uniform size and relatively large diameter. Variations may involve a different number of wires than 9 but the general idea of the term Seale is that there are two layers of wire, the outer layer lying in the valleys of the layer beneath. For ropes of the same diameter, the outer wires of a Seale construction rope are larger components of the strand and thus offer more resistance to abrasion than the same diameter in Warrington. In a modification of Seale, designed for increased flexibility, a strand wire core is used in place of the large core or "king wire" of regular Seale.

(4) *Filler wire.* In filler wire construction, the strand usually has a core wire and inner and outer concentric layers. The interstices between the wires of the inner and outer layers are


6 x 7
6 x 13 Filler wire
6 x 19 Filler wire
6 x 19 Seale patent
6 x 19 Warrington
6 x 19 Wire rope core
6 x 21 Seale patent
6 x 21
6 x 29
6 x 33
6 x 37
8 x 19 Filler wire
18 x 7 Non-spinning
6 x 25 Flattened strand
5 x 9 Flattened strand
6 x 8 Flattened strand
8 x 19 Warrington
8 x 19 Seale patent
Regular lay
Lang lay

Most construction requirements can be met with one of the wire-rope designs shown here. Each offers particular advantages in strength, stiffness, flexibility or abrasion resistance, but none is an all-purpose rope. Choice, therefore, should be based upon careful study and specialist advice.



That wire rope is the lifeline of many a construction job is evident from this typical scene of shovels, hoists and cableways.

filled with wires of smaller diameter which serve to keep the principal wires in position but are not counted on to add materially to the metallic cross-section of the strand. These designs are of more flexible construction than Seale, and where flexibility is of major importance such design types are indicated. The most popular construction consists of 19 main wires and 6 wires of intermediate design.

(5) *Flattened strand.* This construction, developed in England over 50 years ago, was introduced into the United States in 1893. Its strands have a triangular instead of a circular cross-section, an arrangement that allows a greater percentage of wire surface to be exposed to abrasion. In several types flattened strand is stronger than the same size and grade of round strand construction. Also because of its small hemp center and the keystone shape of the strands it offers great resistance to crushing.

Bending and abrasion resistance

In general, resistance to bending stresses increases from a minimum for 6x7 construction to a maximum for 8x19 filler wire construction. Resistance to abrasion, on the other hand, increases from a minimum for 8x19 filler wire construction to a maximum with the 6x7.

A progressive increase in resistance to bending stresses may be listed in the following order of constructions: 6x7; 6x19 Seale; 6x16 filler wire; 6x19 Warrington; 6x19 filler wire; 8x19 Seale; 6x22 filler wire; 6x37 Seale; 6x41; 8x19 Warrington; and 8x19 filler wire. The reverse order lists the progressive increase in resistance to abrasion from minimum to maximum. It should be emphasized that this listing relates only to bending and abrasion resistance and does not take into account other actions to which some types of service subject a rope.

It is noteworthy that 6x19 filler wire construction occupies a middle ground in relation to resistance to bending stresses and resistance to abrasion. Therefore it is widely used in applications where each of these factors is of substantially equal weight.

Field surveys of wire rope practice reveal that some type of 6x19 construction is an outstanding selection in general service. The use of 6x19 wire rope of plow steel or of improved plow steel, in right lay, and with either metallic or hemp center, is so common as to properly be regarded as the "bread and butter" design of the wire rope industry. Such rope, however, is by no means to be chosen off-hand as the best for the great majority of applications in everyday experience; but its popularity is such as to command respect.

Wire for wire ropes

In American wire rope manufacture six grades of steel as listed below are now generally used.

Grade	Approx. Wire Strength Range, lb. per sq.in.
Iron	70,000—120,000
Traction steel	160,000—210,000
Cast steel	170,000—220,000
Mild plow steel	190,000—240,000
Plow steel	210,000—260,000
Improved plow steel	230,000—280,000

Iron dominated wire rope making in the early days, but the development of steel made possible the addition of higher strength grades and also the substitution of soft steel wire in the softer ropes where iron had been used. These softer ropes are now used for such applications as governor and compensating ropes in elevators where their low strength is an advantage. Traction steel ropes are largely used as the hoist ropes in elevators and occasionally for governor ropes also. Cast steel, formerly made in small crucibles from which ingots of varying composition resulted,

is now produced on both sides of the Atlantic by the open-hearth furnace, the resulting product being of much more uniform quality than its predecessor. Cast steel is in fact only a designation of a strength bracket in wire rope classifications, as all modern rope is made of open-hearth steel. The term plow steel, arising in English practice many years ago, as applied to wire rope connotes a high-grade, open-hearth steel. Improved plow steel represents the strongest and toughest material most generally used in wire rope construction.

All the above grades have been standardized by the various specification making bodies, and similar grades of each manufacturer are substantially alike.

While the approximate strength of the individual wires is as indicated above, it is important to realize that the fundamental consideration in rope applications is the strength of the finished rope. Experience and practice have determined the proper minimum breaking strength of each size of rope in the respective designs, and those strengths are shown in the catalogs of all rope manufacturers. The fact that these published values are the same in practically all cases is evidence that these rope strengths and grades have not been arrived at haphazardly, but are the result of careful engineering development.

There are many factors entering into this selection of wire strengths which go back into the technique of steel practice and of the production of the wire itself. Since it is possible by selection of the steel composition, heat treatment and wire drawing practice, to produce steel wire ranging in strength from about 45,000 to as much as 300,000 lb. per sq. in., depending upon the size of the wire, the user would probably be impeding wire rope progress if he confronted the wire rope engineer with such unnecessary hurdles as detailed specifications on steel analysis and wire strength. It is much wiser to explain fully to him the service conditions with which the rope is to compete and then to give him a free hand in the design and the selection of the materials to be used.

Wire rope manufacture

The manufacture of wire rope of specified characteristics depends upon many factors but involves the following major steps:

1. Limestone, iron ore, coke to pig iron
2. Pig iron to open-hearth furnace
3. Steel ingot, from open-hearth furnace
4. Rolling mill, ingot to billet (4 in. sq. and 4½ ft. long)
5. Rod mill, billet to rod (1/5 to ⅜-in. dia.)
6. Wire drawing, rod through dies to wire
7. Stranding machine; wires laid into strands
8. Closing machinery, strands into wire rope

Assuming the proper selection of steel, particularly as to chemical characteristics, the first step in actual manufacture of so-called high-carbon rope wire is proper preparation for drawing. Before the rods are passed through the dies, it is common practice to heat-treat or "patent" them for the dual purpose of securing uniformity of structure and to form a physical structure of the desired type for proper drawing.

After the rods have been patented they are cleaned of adhering scale, given a lime coating and baked at low temperatures to set the coating, all in preparation for drawing them into wire.

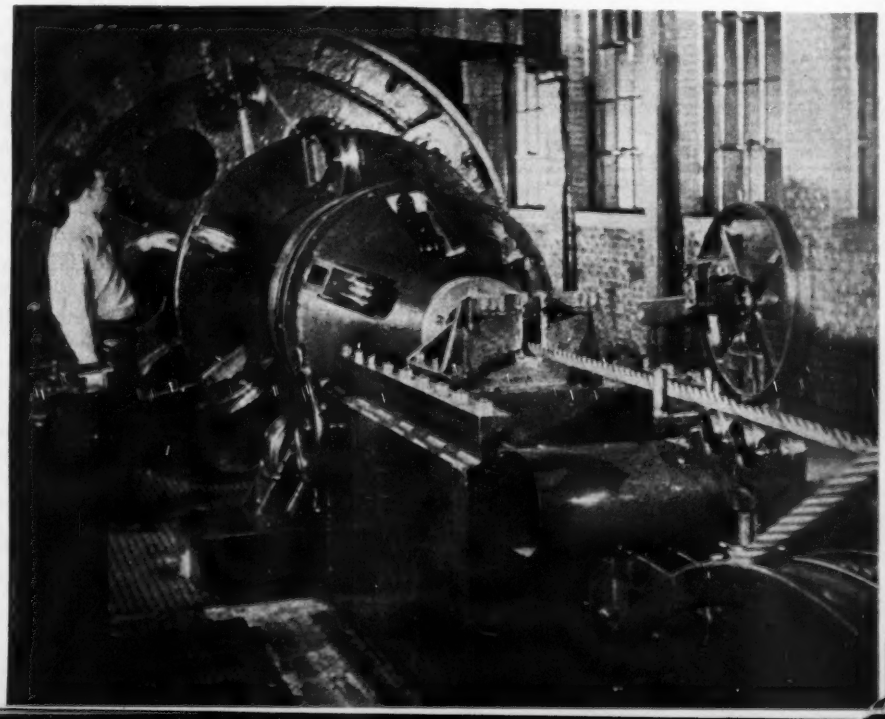
In drawing, the rods are pointed at the ends, and started through conical holes in the dies. The amount of reduction per draft, the speed of drawing and the number of drafts depends upon the diameter and grade of the finished wire and upon the required physical properties. Inasmuch as the drawing process hardens the wire progressively with each draft, it is necessary in many cases, after several drafts have been made, to provide interim heat patenting, including cleaning, coating and baking, which is then followed by the finish drawing to obtain wire of the proper physical properties.

After drawing, the wire is wound on bobbins and sent to the stranding machine, where it is "laid" in one or more layers around the core wire of each strand. In modern stranding machines the bobbins hold their parallelism sufficiently to prevent torsion as the wires are laid into the strands. From the stranding machine where the strands are wound on large bobbins which are placed in the closing machine where the strands are laid into the finished rope. The strands are helically bent around the core, of whatever type, at the entrance of a compression die, the finished rope being pulled through, measured by power-driven drums and stored on shipping reels.

Preforming requires extreme engineering accuracy and skill, and must be checked in each instance because of variations in wire strength and sizes, constructions, lays of rope, etc. The preformed characteristics of the individual wires and strands are developed with the aid of either small sheaves or quills. In the case of the former, the diameter of the sheaves and their spacing is of the utmost importance. In using the quill method of preforming the shape of the grooves is carefully predetermined, based on size, grade and construction of the rope.

Regardless of the method employed the basic purpose of the preforming process is to preshape the individual wires and strands to the curved position they occupy in the finished rope. By this process the component parts of the wire rope are laid together rather than twisted into place by force. The results of the preforming are multiple, chief among which, to quote the chief engineer of one rope manufacturer, is to "make for more flexibility and easier handling. Preformed ropes will not kink so easily and they wind on drums more evenly. The strands of these ropes will stay in place even though the ends are not seized, and broken wires will not protrude. In many cases this type of rope gives greater service."

Wire rope is made on rugged precision machinery that lays the wires into strands and the strands into rope in a continuous operation.



It is customary for makers to test samples of each coil of finished wire for diameter, tensile strength and torsion, and at intervals to test percentage of elongation, bending, hardness and fatigue. In some plants there is now a tendency to omit the bending test in the belief that it does not reveal the quality of the wire as well as do tensile and torsion tests.

In a representative plant it was stated that production is under such close control that a variation of the order of 5 per cent is the maximum to be expected in typical tensile tests of rope sections cut from a batch of the same run. There is a trend in manufacturing circles toward steering away from minimum breaking strength in tabulations in favor of giving a range of values for a particular size, grade and construction.

Recently manufacturers have become increasingly interested in attempts to obtain satisfactory tests of wire rope in severe field service. It is being contended that much field data on wire rope are unscientific and uncertain, and that a real picture of wire rope service calls for a recording dynamometer and a cycle counter. Such tests have been undertaken lately on rope in power shovel service. On a 26-cu.yd. machine graphic records have been obtained showing that the peak demands of the jerk on the rope totaled from 2 to 2.5 times the average. While these tests were not released for publication they indicated the frequency with which such severe strains might occur and from them the wire rope maker was better able to design his product for this type of service. Cumulative failure of strands is the chief danger of subjecting the rope to such severe shocks and impacts.

One of the toughest wire rope services occurs on the familiar pullshovel excavator.

Manufacturers in this country probably possess the major amount of information available to the rope buyer as a guide to selection, and the user is obliged to lean on them heavily for advice. Nevertheless, the relative scarcity of comprehensive and significant field data warrants the independent consideration of this subject by users who desire to talk with the wire rope maker in his own language. The application of wire rope is still a highly empirical affair, and the establishment of better field records is very generally desirable.

Stresses in wire rope

A comprehensive discussion of stress problems has been printed in Technical Bulletin No. 1-30, U. S. Navy Department, Bureau of Construction and Repair, "Instructions for the Design of Wire Rope Installations." It is understood that a new edition of this pamphlet is in prospect this year.

Stress formulas, data and discussions of reserve strength, etc., are also available in the publications of various wire rope makers. One of these publications contains a comparison of 8 bending stress formulas as applied to 1½-in.-diameter 6x19 improved plow steel rope of Lang lay and special Seale construction when operated over a head sheave having a tread diameter of 10 ft. 6 in. The resulting bending stresses vary from 2,100 to 24,555 lb. per sq. in. The discussion is summed up as follows: "It is very apparent that the existent formulas for bending stresses in wire rope do not produce correct results because of the number of variables omitted. It is therefore believed that if in calculating rope stresses, the total static load is increased by the force necessary to accelerate it to the maximum rope speed, and the sheave and drum diameters are set in accordance with practical limits, the magnitude of the bending stresses will represent a negligible factor, having very little influence upon the safety of the rope or the economy of operation."

Renewed emphasis may be laid here upon the importance of studying field experience collaterally with the computation of stresses by the use of formulas available to wire rope engineers and users.

For any particular size and construction of wire rope there is a definite limit to the size of sheaves and drums which may be used. This is known as the critical sheave diameter and may be defined as that diameter below which the rope strands cannot slide past each other to adjust themselves within the bend, and consequently restrictions are set up within the rope. This condition causes excessive critical stresses which are most baffling to mathematical treatment.

Tabulated values for both minimum and critical diameters of sheaves and drums expressed in terms of the ratio to wire rope diameter were given by Spangler in *ENR*, Jan. 4, 1940, p. 50. Rope manufacturers' recommendations are in agreement on all of the common constructions, the more important of which are as follows:

Rope	No. of times rope dia. Min. Sheave Size	Aver. Sheave Size
6 x 7	21	72
6 x 19	30	45
6 x 37	18	26
8 x 19	21	31

One company lists the following major variables that affect stresses and strength: (1) wire sizes; (2) core condition; (3) length of rope and of strand lay; (4) construction; (5) gross metallic area of cross-section; (6) condition and kind of lubrication; (7) size, material, arrangement and condition of sheaves.

Tests and field records show striking variations in rope life under different conditions in these and other variables. Where sheaves were grooved at least ⅛ in. larger than the rope diameter, the rope life was found to be three to four times as long as the life of the same rope when used on sheaves grooved slightly smaller than the actual rope diameter. When a rope is used on equipment having sheaves with tread diameters at or near the point where the strands cannot slide relatively to each other (the "critical diameter" of sheave or drum), service drops off alarmingly. By increasing the tread diameter to economical size, rope service has been increased from five to ten times, depending on the relative speed and upon the presence or absence of reverse bends, with sheaves relatively close together.

Lubrication has been known to increase rope life 2.5 times; change in construction has brought about a 100 per cent increase in life, and so on. In this latter connection, a series of tests made by one company may be cited, in which pre-formed and non-preformed wire ropes were put through reverse

Constructions and Grades of Wire Rope	Non-Preformed Cycles	Preformed Cycles	Per cent Increase
6 x 19 filler wire mild plow steel	26,000	45,500	75
6 x 21 filler wire plow steel	29,600	42,200	42.5
6 x 29 filler wire plow steel	35,200	50,650	43.8
6 x 19 Seale plow steel	16,750	35,250	110.4
6 x 19 Warrington plow steel	14,140	26,850	89.7
6 x 37 plow steel	15,550	26,750	72
8 x 19 Warrington plow steel	16,800	29,550	75.9
8 x 19 Seale plow steel	24,150	49,050	103.1
8 x 19 filler wire plow steel	25,550	43,500	70.5

Small sheaves and sharp angles on carrying scrapers require a rope that resists bending fatigue. Preformed rope is extensively used in this service.

bending cycles at loads of 20 per cent of their breaking strengths, corresponding to a widely used factor of safety of 5. Tests were continued until the specimen had developed 40 visible wire breaks per worst foot. The results are tabulated on the preceding page.

This laboratory investigation indicates that the benefits of pre-forming were greater with ropes containing large, and especially larger, outer wires. Adaptability of preformed rope to applications involving severe conditions of abrasion, and so requiring relatively large outer wires, was thus indicated.

Factors of safety

Obviously, there should be a suitable margin of safety between the total load and the breaking strength of a new rope to allow for reduction in strength due to wear, bending fatigue and corrosion if present. The destruction of life and property that may result from the failure of a rope completely outweighs the cost of providing a rope several times as strong as it needs to be. Experience shows that a wire rope will last longer if the stress to which it is subjected in service never approaches its breaking strength.

Factors of safety are as necessary for wire rope as for all engineering structures or materials. All wire rope companies attempt close calculation of total stresses and base the safety factor on that. In hoisting practice a factor of safety of 5 is common, based on dead-load stress, and this is intended to allow for bending stresses and loss of strength due to wear. Acceleration stresses may, however, require an additional safety margin and should be carefully considered. Where ropes are to run continuously at high speeds and where safety of life is involved, as in the case of high-speed elevators or deep shaft hoists, factors of safety may be 10 or over; for such service the Bureau of Mines recommends that rope be discarded when its factor of safety has decreased to about 5 or 6. All safety factors are intended to be associated with sheave and drum diameters which do not give excessive bending stresses.

In summing up the situation in regard to wire rope stress and safety factors the comments of a representative wire rope engineer are of considerable interest. He says in part: "Possibly because a wire rope has considerably more elasticity than a solid piece of steel, and possibly because this elasticity varies with the age and condition of the rope, it is not possible to compute bending stresses accurately. Our practice is, therefore, to omit bending stresses, and judging this feature by comparison of sheave and drum ratios for the particular class of equipment under consideration, along with accumulated data on previous installations, to work to a safety factor which experience tells us is satisfactory for this particular type of equipment. This means that in dealing with engineering on wire rope there is no substitute for practical experience and familiarity with rope application."

Field inquiries indicate that in general the catalogued strengths of wire rope are thoroughly reliable for engineering computations, and also that a very large percentage of wire rope applications are made on the basis of experience, with a minimum attempt to calculate other than tensile stresses, allowing liberal factors of safety to offset the uncertain elements in the individual case. Judgment enters the picture to a high degree in determining type, size, material, center, lay and construction. Some large users and many smaller ones do not attempt to buy wire rope on a specification basis, but purchase mainly on service records and life data for particular applications. The quality of these records varies from tables of carefully prepared data to fragmentary memoranda on scratch pads. Cut-and-try methods are widely prevalent.

Selection problems

The choice of wire rope for a particular service may properly be influenced by experience in addition to estimates of anticipated stresses. In many cases the selection boils down to a compromise between ability to resist bending fatigue and ability to resist abrasion, extremes in constructions being typified by 8x19 filler wire and 6x7 type ropes.

Warrington construction (3 sizes of wire per rope) is largely recommended for use on tackle blocks, boom falls and slings. 6x19 Seale meets conditions where higher resistance to abrasion and a more rugged rope body are needed. The larger size of the outer wires contributes to longer wear, and crushing strains on drums are more readily resisted than with Warrington, but at some sacrifice in flexibility. By preforming Seale construction, however, this lack of flexibility can be overcome. Among the recommended applications of Seale construction are draglines, track lines on cableways, inclines, scrapers and winches.

Increased flexibility and resistance to

bending fatigue characterize 6x19 filler wire rope, and this can be found in many applications where sheaves and drums are relatively small in diameter, and where abrasion is not extreme. Such equipment includes shovel hoisting ropes, boom falls, car retarders, car dumpers, derricks, coal hoisting towers, elevators, grab buckets, hoists, winches, slings, draglines, trench hoes, and pile drivers. 6x19 armored rope, having a serving of flat annealed steel wire around each strand, is used at times on dredges and derricks; the armor provides some degree of resistance to abrasion even after being worn through at the crown of the strand.

6x37 Seale construction is useful where highly flexible rope is required, and applications will be found on grab buckets, mining machinery, dipper dredges and shovel hoists. The 6x37 filler wire rope is more flexible, but in general this construction has less ability to resist abrasion than 6x19 rope.

A number of 8-strand constructions are also available for service where increased flexibility is required, most of these being variations of 6x19 construction. A few of these listed by a prominent maker include 8x19 Warrington, used on pavers and mixers; 8x19 filler wire, employed in crane and hoist service; and 8x19 Seale, employed in elevator work and marine service. Another construction of interest is classed as 18x7 non-rotating rope, for use in hoisting unguided loads. Such construction usually consists of 18 strands of 7 wires each, the special feature of its design being that the 6 inner strands left lay while the 12 outer strands are right lay.

For ordinary work hemp centers are widely used, but where more solidity or excess strength is required, or where high unit pressures are encountered, the wire rope center and the metallic core are desirable. A steel center is also indicated where severe heat is encountered by a wire rope. One prominent wire rope maker sets a border line at 18,000 lb. compressive load on the hemp center as marking the desirability of using a metallic core. Power shovels are referred to as outstanding examples of wire rope center application.

In regular lay, where the wires in the strands are laid in the opposite direction to the strands in the rope, comparatively short lengths of wire are exposed on the outer surface of the rope. In the case of many ropes used in construction work, and subjected to serious abrasion, Lang lay rope is employed because a considerably greater length of wire is exposed on the outside to take this abrasion. It is also asserted that the greater bearing surface offered by Lang lay ropes minimizes the wear on sheaves and drums. However, in this connection it should be noted that regular lay presents more strand crowns to the wearing surface than does Lang lay.

Another argument in favor of Lang lay is that it can be used on smaller sheaves and drums than regular lay because the length of lay covers more of the sheave tread circumference than is the case with regular lay. Lang lay requires first-class winding conditions on small drums, and is less desirable in this service where multiple layers are employed; on large drums this is not the case, and the ability of Lang lay to withstand greater abuse recommends it. It is not considered good practice to use it with a swivel end on account of kinking tendencies. Much is to be said in favor of pre-forming Lang lay rope to overcome crankiness and kinking.

In flattened strand rope, the strands have a triangular cross-section instead of circular. This arrangement allows an increased percentage of wire length and a flat instead of a knuckled surface to be exposed to abrasion; in many situations therefore longer life results than with round strand rope. For services where crushing loads are severe flattened strand construction also offers advantages. Finally the smooth area formed by the strand wires minimizes wear on drums and sheaves.

When purchasing wire rope

The above discussion of wire rope selection should be considered principally as background information for ordering, at which time the recommendations of the manufacturer's wire rope engineer can be called upon.

When ordering rope the following information should be given the manufacturer: (1) length, (2) diameter, (3) construction, that is, type, such as Seale, Warrington, etc., and the number of strands x number of wires in each strand, (4) grade, whether cast steel, plow steel, etc., (5) right- or left-hand lay, (6) regular or Lang lay, (7) pre-formed or non-pre-formed, (8) hemp or wire rope center, (9) class of service in which rope is to be used.

Care of wire rope

Wire rope like any other product used in construction can be abused, and if maximum service is to be obtained the principal kinds of abuse should be recognized. First in point of time is the unreeling of the rope when it arrives on the job. It is absolutely necessary that no kinks be formed, for no amount of load will remove them completely and they comprise points of decreased strength. Best procedure is to insert a shaft through the reel and pull the rope off, care being taken always to keep tension on the line. Standing the reel up and removing the wire loops over the end is particularly dangerous, as is the practice sometimes followed of pulling the rope from the center of the coil. Avoid kinks at any cost.

Handling of the rope in service may also be either good or bad. More hoist ropes are damaged by sudden jerks than by wear. When a rope has been in service for some time it becomes necessary to examine its condition carefully. Such a check-up should seek to discover if there has been any undue stretching or if broken wires are present. Wire breaks may be detected visually or by running waste along the rope. The latter is a particularly good way to discover breaks in pre-formed rope in which the wires do not splay out as they do in non-preformed.

Finally and most important from a service standpoint is lubrication. Three principal parts of the rope are to be considered, the center (hemp or independent wire rope), the strands and the rope as a whole. During manufacture these parts are lubricated separately and by various procedures according to the makers' practices. Hemp centers receive special attention because lubrication is absolutely essential to preserve the hemp; also squeezing of the hemp center under load may be expected to supply some internal lubrication to the rope. A dry core will both wear and crush more easily than a lubricated one and in addition will absorb moisture.

Even though special attention is given to lubrication of wire ropes during manufacture and the best possible lubricant used, it is not possible for the factory lubrication to last the life of the rope. Field lubrication therefore is necessary.

Before a lubricant is applied the rope should be thoroughly cleaned to remove dirt and gummed lubricant from the valleys between the strands. Superheated steam (because of its freedom from moisture) or compressed air are good cleaning agents.

The object of lubrication should be to obtain thorough penetration and to protect against corrosion. The lubricant used should be thin enough to secure this penetration but not so thin as to run off the rope. Consequently a semi-plastic compound applied hot in a thinned condition is usually best; when it cools it stays in the rope and also serves to exclude water. The best way to apply it is to run the rope slowly through a heated tank of the lubricant.

There are, however, cold lubricants that are satisfactory. Some are applied with a brush, others can be poured on and spread. One procedure is to use a thinned heated lubricant for penetration and then a heavier lubricant to seal the crevices and keep out moisture.

A number of the oil companies have published booklets on lubrication practices that not only recommend the proper grades of lubricant but outline field methods of application. With lubrication problems, as with wire rope selection, seeking the advice of a specialist is worth while.

FROM FIELD AND OFFICE

Working problems and time-saving methods . . . Edited by Charles S. Hill

Rapid Steel Erosion

WILLIAM and HENRY EIPEL
New York, N. Y.

The accompanying illustration is a startling example of rapid steel erosion in a Turkish bath building at Coney Island, N. Y. The building is 17 years old and the floor framing between 30x90-ft. walls is 20-in. I-beams 16 ft. apart spanning the 30-ft. width and carrying 8-in. I-beams spaced 6 ft. apart. The 8-in. beams supported a 4-in. cinder-concrete floor reinforced with wire mesh. Flaking concrete warned of trouble and after disclosures from a preliminary examination by architect and engineer the entire floor was ordered vacated and temporary shores placed under the beams. The concrete slabs were then removed and it was seen that almost every beam was corroded at some point. Completely disintegrated webs and flanges (as shown by the accompanying illustration) were evident in the beams. One could press on the webs of the 20-in. girders and push the entire web through with no great effort. Where the disintegration was not complete large rust flakes could be removed by hand.

The source of this condition went back only 6 or 7 years, when the floor was first used to accommodate stalls of individual hot-salt-water bathtubs. The floor was covered with waterproofing and then a layer of tile set in 2 in. of fill. The constant splashing and overflowing of the salt water from the tubs had continuously kept the floor wet. The water had found its way into cracks in the tile floor, corroded the waterproofing and then had seeped into the cinder-concrete slab. The action of the water in the cinder-concrete slab had corroded the steel until the condition was investigated.

The entire floor is being renewed under the supervision of the writers for Louis S. Weeks, the architect.

Steel frame of cinder concrete floor after seven years of salt-water dripping.

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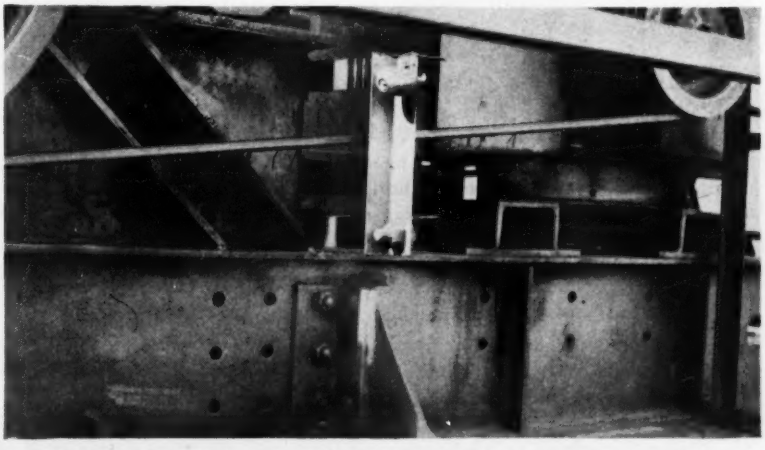
Theft-Proofing V-Belts

ELTON STERRETT
Longview, Tex.

Even when supposedly protected by a night watchman on the job, serious delays were experienced by one contractor through continued theft of V-belts from his compressors, lighting units and field water supply pumps. It was suspected that the stolen belts were being disposed of at nearby oil fields for use on pumping units, but knowledge of probable destination failed to halt the annoying delays while replacements were being sought and installed.

Finally each V-belt drive was padlocked in place so that it could not be removed without being cut and its re-use thus prevented. On the portable compressor units, for instance, a bracket was welded to the top of the skid beam, and another to the end of the housing supporting and enclosing the power unit. The lower bracket was bored for a ¼-in. bolt, and the upper to take the hasp of a sturdy padlock. A locking bar, of 2x2-in. angle iron, was pivoted to the lower bracket and, with matching hole



Pivoted bar and padlock spans the V-belts on this field compressor drive and prevents theft.

BRIEF MEMORANDA

"Having occasion to move a 1-in. service line, which was connected to an 8-in. main located under a paved street in a commercial district, we were confronted with the problem of breaking the pavement or shutting down the 8-in. line, neither plan being very satisfactory because of the large area being served by the 8-in. line. We decided to experiment; we secured about 1 lb. of dry ice, placed several thicknesses of paper under the 1-in. pipe, then placed the dry ice around the pipe, folding the paper around the ice. In about ten minutes the pipe was frozen solid. We cut the pipe and put the new line in place with a curb cock at the meter setting. We then uncovered the ice and poured water on the pipe, that is, the frozen section, until the meter began to turn. The entire operation took about 30 min. and saved a lot of hard work, expense and inconvenience."—B. C. GOSNEY, *superintendent of water, Auburn, Wash. in* "Water Supply and Sewerage News", *State Department of Health, Seattle, Wash.*

at the top, was held in place by the padlock, effectively enclosing the belts in a square formed by base beam, frame and angle iron. To replace the belts, it was necessary only to unlock the padlock and rotate the bar out of the way around the bolt at its base. Unauthorized removal of this bolt was forestalled by welding the nut to the bolt threads after tightening.

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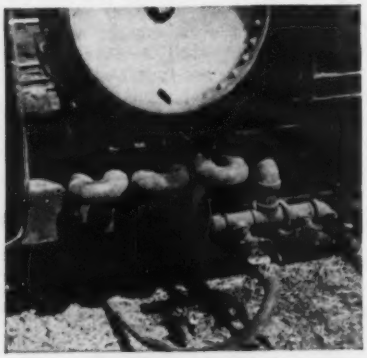
Home-Made Aftercooler

K. N. Banthin
Contractor, Cravitz, Wis.

Complaint of hot air in drilling for an excavation job led to the device illustrated. Two portable compressors were operating under an over-



Improvised aftercooler prevents heating of pneumatic drills.

load and found but brief periods to run idle, and something had to be done about the air to the drills. The solution was the coupling together of some 2-in. return ells and lengths of pipe to form an aftercooler.

As the result of this experience we have constructed aftercoolers on all our compressors and have found it possible to operate them at an overload for considerably greater periods. The illustration shows an aftercooler on a 116-cu.ft. unit. This aftercooler is constructed out of seven 40-in. lengths of 2-in. extra heavy pipe with steel return ells, 90 deg. ells and tees.

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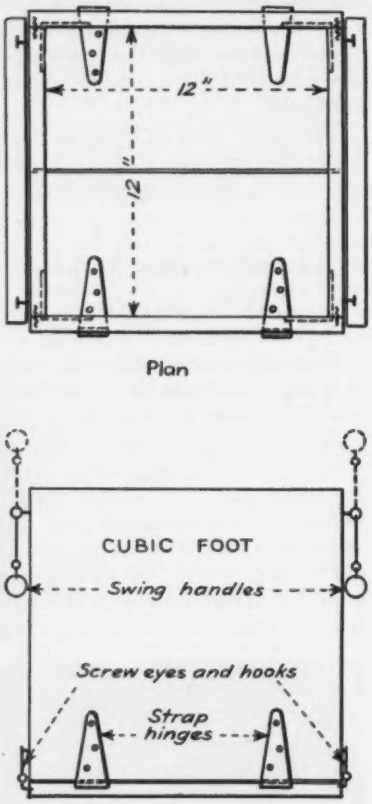
A Dump-Bottom Cubic Foot

H. D. Hurley
Massachusetts Department of Public Works
Boston, Mass.

One of the tools needed in construction is a measuring box for loose materials. Its most common use, of course, is in aggregate study for concrete proportions. Often, only an odd-size improvised container is at hand with resulting inconvenience in arriving at conclusions. To have something better the writer recently designed and built the box illustrated



Details of a cubic-foot measuring box having a dump bottom.

which has the following important features: inexpensive materials; sturdy construction; decimal divisions; two-man handles and a dump bottom.

The sides and bottom of the box are of 5-ply plywood salvaged from old forms. The sides are connected by inside corner angles and corrugated fasteners. The bottom is in two parts which rotate to full opening on strap hinges but which are locked in the closed position by screw eyes and hooks placed in a handy location on the outside of the box. Two handles, made from a discarded hoe handle, are attached to the box by screw eyes and hooks so that they hang against the sides when not in use leaving the top edge free for screeding but they swing up easily into lifting position when required, and give ample hand room for two men. The inside surfaces are smooth because the angles and hinges are countersunk, a simple process with plywood due to the ease of removal of a portion of one layer of the material.

The box is a full cubic foot in size, but copper tack markers permit the measurement of tenths if necessary.

Field & Office Comment

Not a New Test

Sir: The method of load testing piles described in the article, "Novel Pile-Test Loading," (*ENR*, Feb. 1, 1940, p. 183) is an interesting one but some question might be raised as to whether or not it is novel.

About two years ago in an article, "Jack Setup for Pile Test" (*ENR*, Mar. 3, 1938, p. 344) the writer described a similar method used by the U. S. Engineers for load testing wooden piles during construction of the many locks and dams in the upper Mississippi River.

The U. S. Engineers' tests utilized two adjacent piles for anchors instead of driving special ones; a 30-in. beam with stiffeners over the jack and under the bearing blocks, and cables instead of straps to tie the beam to the anchor piles (holes being bored in the anchor piles for the cables to pass through). A wood box was fitted over the cable to protect workmen in the event of a cable snapping under load, otherwise the setup looked much the same as that pictured in the author's article. The 30-in. beam, jack, cables, etc. were hauled from one project to another and used on many (perhaps all) of the lock and dam sites in the upper Mississippi district.

These tests were made at least as early as 1934, at which time the writer was connected with the U. S. Engineer office and observed (as an inspector) those performed at Lock No. 7 where 75-ton loads were maintained for over a week with any adjustments necessary being made every 10 min.

Russell C. Brinker
Assistant Professor of Engineering,
University of Hawaii
Honolulu, T.H.

BOOK NOTES AND REVIEWS

The month's additions to the engineer's reading and reference list

Brick in Construction

BRICK ENGINEERING—By Harry C. Plummer and Leslie J. Reardon. 400 pp. Published by the Structural Clay Products Institute, Washington, D. C. Price $4.

This design handbook has been prepared by the Structural Clay Products Institute to bring together in convenient form the widely scattered data on brick as an engineering material, especially the results of recent research in the use of reinforced brickwork. All the major uses of structural brick are covered as are waterproofing, mortars and such troublesome questions as efflorescence. There are many charts and diagrams and useful table of the properties of brick.

Law for Engineers

LEGAL ASPECTS OF ENGINEERING—By Walter C. Sadler. 631 pp. Published by John Wiley & Sons, Inc., New York. Price $4.

Mr. Sadler's book is primarily a collection of cases, with an appended glossary for the convenience of the non-legal reader. In his preface the writer disclaims any attempt to equip the reader for the practice of law; he does aim to give a general understanding of certain branches of law pertinent to various business and professional aspects of engineering. It may be said at once that he has achieved this general objective.

An advocate of the case-book rather than the text-book approach to his subject, Mr. Sadler analyzed some 6,500 legal cases dealing with engineering subjects and from them chose the 300-odd cases which largely comprise his book. The material is divided into five parts covering professional and industrial problems, aeronautics, property and business.

These cases are interesting and informative. They touch upon subjects vital to the engineer. But just here lies the difficulty common to general treatises: the limitations of space preclude any but the sketchiest coverage.

"Legal Aspects of Engineering" can be recommended as a pleasant excursion along some of the highways of engineering law. Inevitably it neglects the less known and therefore more treacherous byways, and makes it once more necessary to warn the unwary that a little knowledge is a dangerous thing. — *Reviewed by* ALEXANDER HARING, *Contractor's Consultant, New York City.*

Handbook on Cities

MUNICIPAL YEARBOOK, 1940 — Clarence E. Ridley and Orin F. Nolting, editors. 629 pp. Published by the International City Managers Association, 1313 East 60th St., Chicago. Price $5.

Containing a wealth of information on the activities of American cities, the 1940 issue of the Municipal Yearbook is an invaluable source book of statistics and developments relating to local government administration. In addition to broad survey articles there are many special sections dealing with model ordinances, sources of municipal statistics, services available from federal and national agencies, and a standard list of references in each field of municipal activity.

New material incorporated in this edition provides data on civil service agencies, centralized purchasing, annual municipal reports, city planning, low cost housing, and parking meter revenue statistics. Detailed information is given on refuse collection and disposal practices in 165 cities.

Contract Relations

BUSINESS METHODS IN THE BUILDING FIELD—By George Schobinger and Alexander Lackey. Published by McGraw-Hill Book Co., New York. Price, $3.50.

The title is not descriptive of the full content of the book as it covers all relations of the owner, architect or engineer, and builder, and gives worthwhile suggestions on the interrelated function of each in economic building. The book explains the advantages and disadvantages to the owner of the agency and guaranteed price contracts with their several variations and details of the risks taken by owner and builder under each. Indicative of the tenor of the book is the following statement, "The primary and fundamental responsibility of the owner is the selection of the architect, engineer, and builder, and to do so merely on the basis of price is to sacrifice the greatest opportunity for attaining the sole objective—a job of the desired quality, when wanted, at the lowest overall cost."

Comparative sections of contracts are shown to illustrate possible simplification and still retain essentials. Surety bonding and insurance are competently covered with a suggestion on who should carry each of the desirable types. Preliminary estimating to determine the economic feasibility of a project is discussed. A syllabus of business procedure, including outlines of organizations and information required, followed by a long check list for planning or bidding make the volume a valuable handbook for the architect.

Transport Subsidies

PUBLIC AIDS TO TRANSPORTATION —Vol. I, General Analysis; Vol. II, Aids to Railroads; Vol. III, Aids to Transportation by Water; Vol. IV, Aids to Motor Vehicle Transportation. Prepared by the Section of Research, Federal Coordinator of Transportation. For sale by the Superintendent of Documents, Washington, D. C. Price 60c per volume.

HIGHWAY COSTS and Motor Vehicle Payments in Massachusetts, Connecticut and Rhode Island—By C. B. Breed. Published by the Trustees of the Property of the New York, New Haven & Hartford R. R., New Haven, Conn.

Much has been written and said in recent years about public subsidies to various types of transport, especially highways and waterways, but the conclusions of the individual speakers or writers have been so diverse as to confuse rather than to clarify the issue. The two reports noted above are an example. The staff of the Federal Coordinator of Transportation finds that since 1926 motor vehicle users as a class have received no public aid, though certain vehicle groups have not paid their way. The Breed report, on the other hand, finds that for three New England States the highway users have received $509,000,000 in subsidies in 28 years. A companion study made by Prof. Breed in association with Clifford Older and W. S. Downs for the Association of American Railroads in 1938 [Highway Costs] put the subsidy for the nation in the period

1921–1932 at nearly ten billion dollars. This great difference, according to the coordinator's staff, is due to a combination of many items, but principally to a marked overstatement of the responsibility of motor-vehicle users for road and street costs, use of costs far too high for rural roads in existence on Dec. 31, 1920, and the inclusion of taxes as an element of highways and street costs.

The report of the Federal Coordinator of Transportation is the most complete and comprehensive yet made. Its major value lies in the fact that the methods used are set forth in detail together with explanations of why they were used in preference to other methods such as those in the railroad reports. The report contains much valuable information on the service life of various types of pavements.

Dream Highways

MAGIC MOTORWAYS—By Norman Bel Geddes. 297 pp. Published by Random House, Inc. New York. Price $3.50.

Hindsight is so much more accurate than foresight! Norman Bel Geddes, creator of the Futurama at the New York Worlds Fair, complains that none of the early roadbuilders of this country had any vision; they built only to satisfy their immediate needs and did not look ahead to the time when high-speed vehicles would be hampered by crooked roads, steep grades and numerous intersections. The hard fact that highway builders never have had sufficient funds to build the roads adequate for their immediate needs is ignored by Mr. Geddes. But costs do not throttle Mr. Geddes imagination, which is understandable when it is realized that his highway building experience has been limited to the General Motors Futurama where a tunnel several miles long can be driven in a few minutes with the aid of a carpenter's auger, a little plywood and plaster.

"Magic Motorways" is little more than a very cleverly presented argument for a network of air-line superhighways criss-crossing the country, a scheme similar to those which were rejected by the Public Roads Administration in its report to Congress last year. Superficially, Mr. Geddes appears to put forward a program of highway building that, if followed, would end congestion and greatly reduce our accident toll. But actually his chief concern is for the long-distance traveler. Speed is the controlling factor in his thinking. Billions of dollars are to be spent on six and eight-lane highways to permit a small part of the nation to drive across country at 75 and 100 mph. The obvious result would be to deprive the great bulk of the people of much needed improvements and additions to local roads. And even on the subject of superhighways Mr. Geddes adds nothing of practical value that is not already accepted as sound practice by our state and federal highway engineers.

Public Works Year Book

PUBLIC WORKS ENGINEER'S YEAR BOOK, 1940—Published by the American Public Works Association, 1313 East 60th St., Chicago, Ill. 338 pages. Price $3.50.

Problems and practice in public works fall under the scrutiny of authorities in the field at the Public Works Congress sponsored by the American Public Works Association each year. After the experts have aired their views, the men on the firing line of public works administration and operation have an opportunity to raise questions and ask advice. A complete report of these happenings forms a substantial part of the Year Book. In addition, the book contains discussions on special topics not covered at the meetings, and a roster of membership.

The 1940 proceedings include papers on the preparation of long-range programs, control of subdivision development, traffic control and safety island design, low-cost pavement construction, and the sanitary fill method of refuse disposal.

Water Treatment

WATER QUALITY AND TREATMENT MANUAL—300 pp. Published by the American Water Works Association, 22 East 40th St., New York, N. Y. Price, $3 (to association members, $2.50).

Fifteen years have elapsed since the American Water Works Association issued its Manual of Water Works Practice. The new manual, dealing specifically with water quality and treatment, is a complete revision of material originally included in the former text.

This book represents the combined effort of a committee of waterworks specialists organized under the leadership of Paul Hansen, consulting engineer, Chicago. Carefully edited by the late Prof. L. V. Carpenter of New York University in cooperation with Harry E. Jordan, secretary of the association, it provides a complete and authoritative summary of treatment procedure.

In addition to discussions on various treatment methods and their application, the book contains chapters on organisms in water and natural purification processes occurring in streams and lakes.

MISCELLANEOUS NOTES ON BOOKLETS AND REPRINTS

THE BIBLIOGRAPHY of American hydrology for 1939 has been completed by the American Geophysical Union. Copies will be available about July 1 and may be obtained from 5241 Broad Branch Road, N. W., Washington, D. C. Price, 50c.

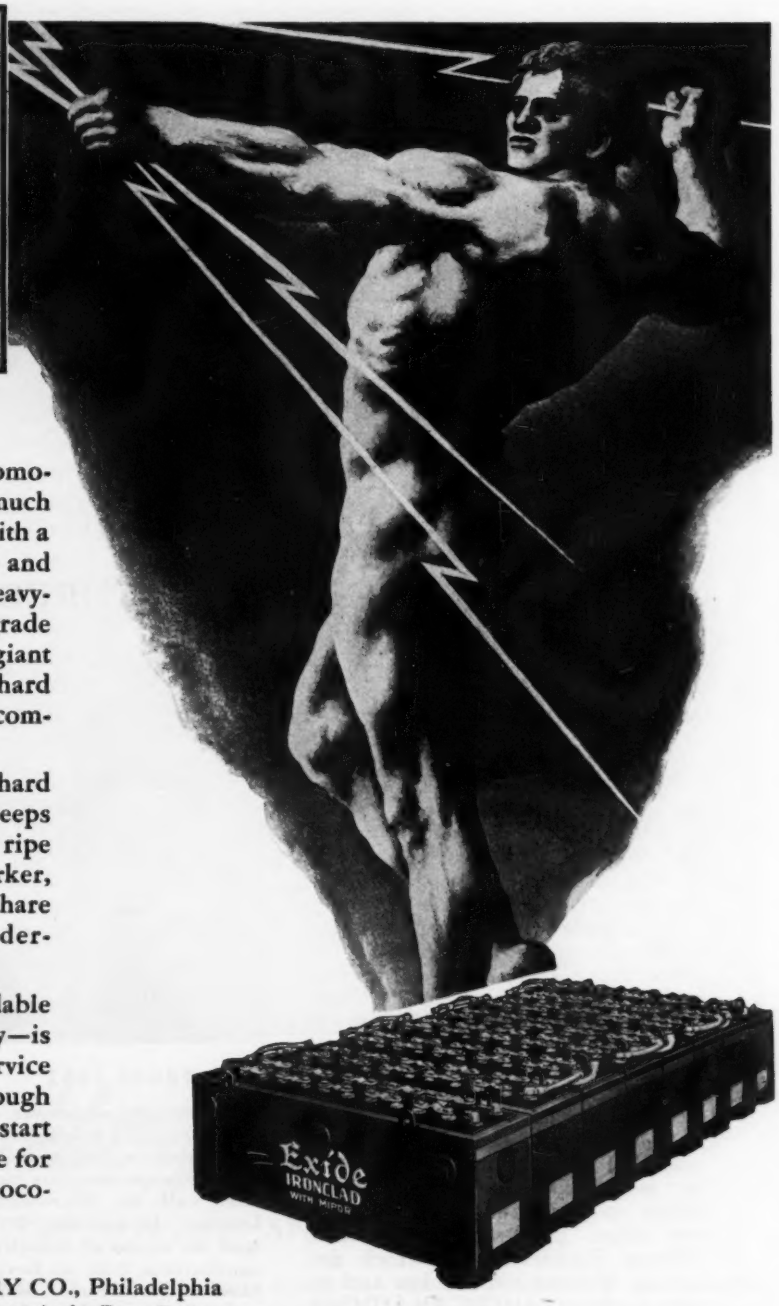
ROADSIDE DEVELOPMENT, reports and papers presented at the 19th annual meeting of the American Association of the State Highway Officials, have been published by the Highway Research Board, National Research Council, Washington, D. C., in pamphlet form. Price, 50c.

THE PROBLEM OF LOCAL LEGISLATION is discussed in a joint report of the Maryland State Planning Commission and the Legislative Council. The report outlines ways for reducing the volume of local legislation. Copies may be obtained from the Planning Commission, Baltimore, Md.

THE STRUCTURAL PROPERTIES of numerous building materials are being studied currently by the National Bureau of Standards and the findings are being issued in pamphlets entitled "Building Materials and Structures." Copies may be obtained from the Superintendent of Documents, Washington, D. C., for the price indicated. Among the recent pamphlets are the following: Structural Properties of Reinforced-Brick Wall Construction and Brick-Tile Cavity-Wall Construction (10c.); Conventional Wood-Frame Construction for Walls, Partitions, Floors and Roofs (15c.); Plywood Wood-Frame

(Continued on p. 82)

The giant that lives in a box...



AN EXIDE-IRONCLAD locomotive or trammer battery looks very much like a black box . . . but it is a box with a giant inside it. A giant of strength and endurance, who can take a train of heavy-laden cars and push them up a grade while scarcely exerting himself. A giant who can start in the morning, work hard and fast all day, and end up just comfortably tired.

He is a durable giant, used to hard knocks and rough usage. And he keeps the full strength of youth far into a ripe old age. He is a willing, faithful worker, and he does, in fact, perform a large share of the nation's haulage work underground.

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DALLAS—1118 Jackson St.
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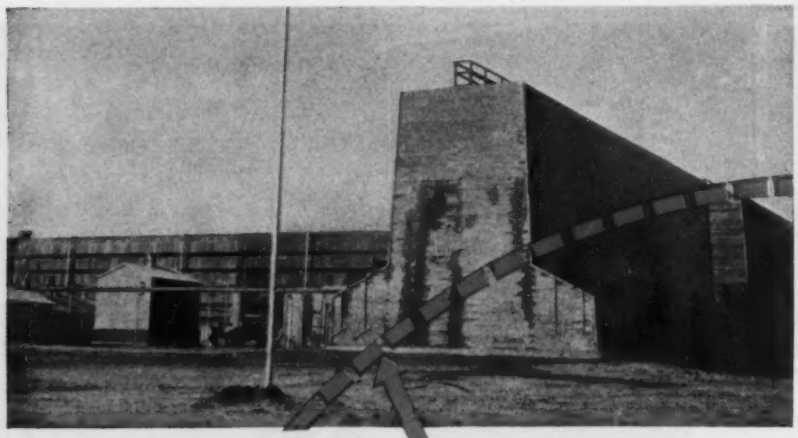
NEW ORLEANS—428 Baltor Bldg.
NEW YORK—23-31 W. 43rd St.
PHILADELPHIA—Allegheny Ave. and 19th St.
PITTSBURGH—1078 Union Trust Bldg.
ST. LOUIS—1218 Olive St.
SAN FRANCISCO—6130 Third St.
SEATTLE—1919 Smith Tower Bldg.
WASHINGTON—1819 L Street, N.W.



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MISCELLANEOUS NOTES ON BOOKLETS AND REPRINTS

(Continued from p. 80)

Wall Construction (10c.); Brick-Concrete Block Wall Construction and Concrete Block Walls (10c.); Plastic Calking Materials (10c.); Celotex Wall Construction (10c.).

CURRENT PROBLEMS AND PRACTICE in sewage disposal discussed at the Ohio Conference on Sewage Treatment are reported in a 150-page book, copies of which are available at $1.25. Address: A. H. Niles, Sewage Treatment Plant, Toledo, Ohio.

A SYSTEM of classifying traffic engineering materials to aid traffic engineers in the establishment of a record system and in organizing the filing of published material has been published by the Bureau of Street Traffic Research, Yale University, New Haven, Conn., under the title "Library Classification, Yale Traffic Bureau, Series No. 1." Price, $1.

NEW ENGINEERING BOOKS

PUBLIC WORKS ENGINEERS' YEARBOOK 1940—338 pp. and index. Published by American Public Works Association, Chicago. Price $3.50.

EROSIONAL TOPOGRAPHY AND EROSION—By James M. Little, E.M. 104 pp. Printed by A. Carlisle & Co., San Francisco.

ECONOMIC ENGINEERING—THE MASTER WAY—By Herman Van Polen. 55 pp. Published by the Christopher Publishing House, Boston. Price $1.25.

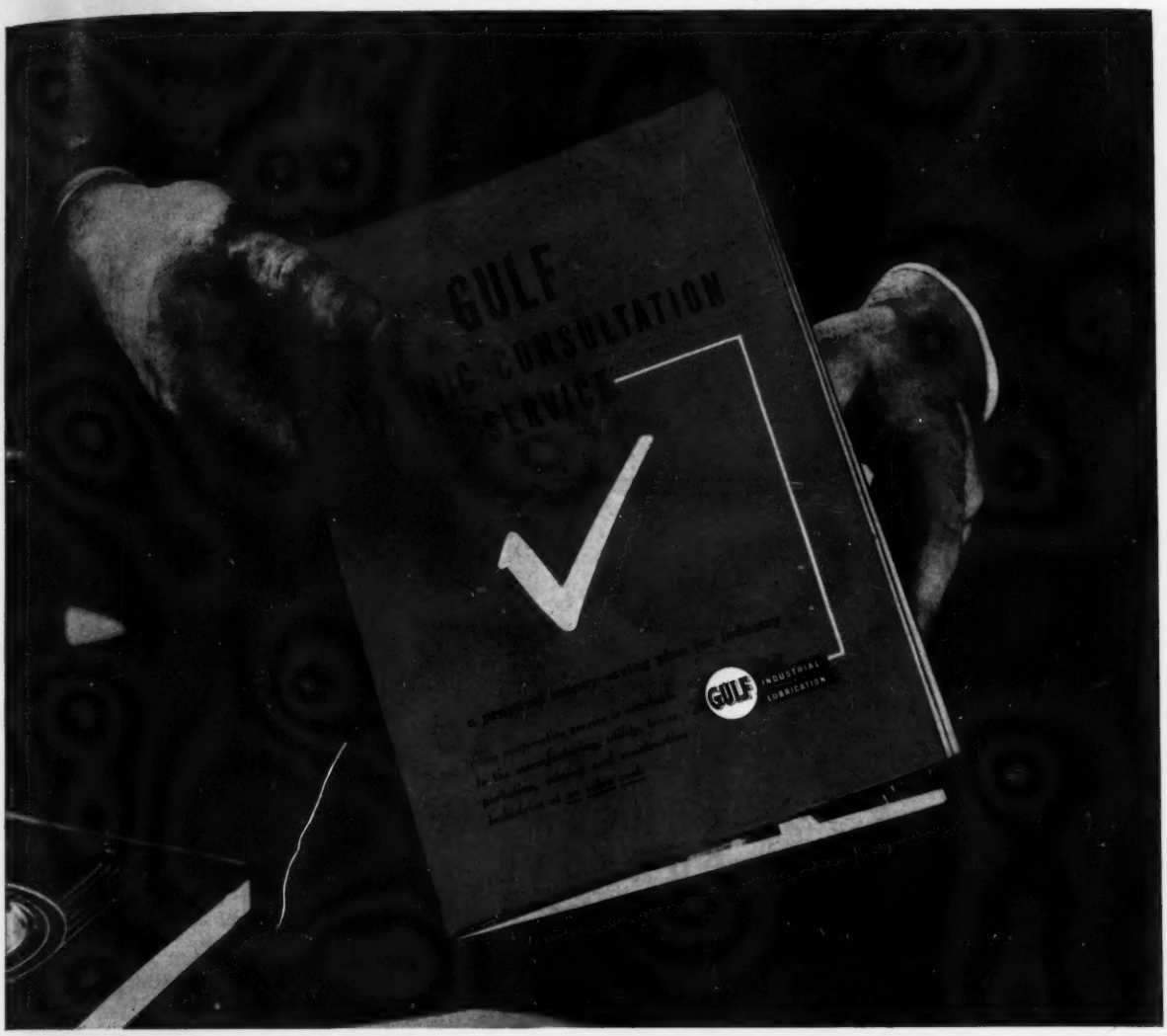
MODERN BLAST CLEANING AND VENTILATION—By C. A. Reams. 213 pp. Published by the Penton Publishing Co., Cleveland. Price $4.

REPORTS AND PAMPHLETS

STRUCTURAL ANALYSIS LABORATORY RESEARCH—1938-39. Serial No. 68, Dept. of Civil and Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

A REVIEW OF RAILWAY OPERATIONS IN 1939—Reprinted from *Railway Age* by Association of American Railroads, Bureau of Railway Economics, Washington, D. C.

(Continued on p. 84)



The "Booklet-of-the-Month"

FOR OPERATING OFFICIALS AND ENGINEERS

HERE is news for cost-conscious executives who are harassed by higher "non-controllables." With costs up and profits in the squeeze, operating men are welcoming this practical plan which they can put to work *immediately* to reduce the "controllables."

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PERFECT GRIP • DROP FORGED STEEL • HOT DIP GALVANIZED safe since 1853

DEALERS WITH STOCK IN ALL PRINCIPAL CITIES

(Continued from p. 82)

REPORT of Committee on Aims and Scope of Engineering Curricula. May be obtained from the Secretary, Society for the Promotion of Engineering Education, University of Pittsburgh, Pittsburgh, Pa.

THE PORT OF MILWAUKEE, WIS.—Lake Series No. 3. Prepared by The Board of Engineers for River and Harbors, War Dept., Washington, D. C. May be obtained from the Supt. of Documents, Washington, D. C. Price 55c.

BOWRON'S DIMENSION TABLES FOR REINFORCING BARS—By Charles E. Bowron, Birmingham, Ala. Price, $1.

DETECTION AND CONTROL OF SILICOSIS AND OTHER OCCUPATIONAL DISEASES—Progress report to the Legislature of the State of New York. Submitted by Frieda S. Miller, Industrial Commissioner, Albany, N. Y.

SURFACE-WATER RESOURCES OF THE TERRITORY OF HAWAII—1901-38. Prepared by Territorial Planning Board, Territory of Hawaii, Honolulu. Price $1.50.

EXISTING URBAN RESOURCES AND FACILITIES OF THE TERRITORY OF HAWAII—Prepared by The Territorial Planning Board, Territory of Hawaii, Honolulu. Price 75c.

METHODS OF MOISTURE CONTROL and Their Application to Building Construction—Bulletin No. 17. Published by Engineering Experiment Station, University of Minnesota, Minneapolis.

AMERICAN LABOR AND THE TRADE AGREEMENTS—Distributed by Economic Policy Committee, Des Moines, Iowa.

PROCEEDINGS OF HYDRAULICS CONFERENCE—Bulletin No. 20, Studies in Engineering. Published by State University of Iowa, Iowa City.

A STUDY OF THE FIRE RESISTANCE OF BUILDING MATERIALS—Bulletin No. 104, Engineering Experiment Station, Ohio State University, Columbus. Price 60c.

FACTS ABOUT UNEMPLOYMENT—Social Problems, No. 4, 1939. Federal Works Agency, Works Projects Administration. Published by Superintendent of Documents, Washington.

PREPARATON OF REFUSE FOR COLLECTION—Bulletin No. 9, American Public Works Association, Chicago. Price 50c.

HIGHWAY CONFERENCE PAPERS' University of Colorado—Conference at Boulder, Colo. Jan. 18-19, 1940. Copies obtainable through C. L. Eckel, Department of Civil Engineering, University of Colorado, Boulder.

ASPHALT RAILROAD BALLAST—Asphalt Institute Information Series No. 37.

WHO SAID "Wire Rope Reeving Isn't Important"?

BEFORE 4" rollers at reverse bend. Rope service unsatisfactory.

AFTER 17" sheaves replaced the 4" rollers.

RESULT Rope Service almost Doubled!

This is an *actual* case history. Not an isolated case. But a typical example of what can be and is being done to increase rope life through proper wire rope reeving.

There is nothing complicated about proper wire rope reeving. It's simply a matter of watching the things that are easily overlooked—avoiding reverse bends whenever possible, making sure that sheaves are large enough, that sheave grooves are in proper condition, etc. The additional examples to the right are typical of what can be done. And they pay big in results.

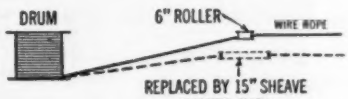
To obtain maximum safety and service from wire rope—watch wire rope reeving. And feel free to consult our local representative—who will gladly make available to you our years of experience with every conceivable kind of reeving problem. His suggestions may point the way to worthwhile savings.

JOHN A. ROEBLING'S SONS CO.
Trenton, N. J. *Branches in Principal Cities*

This advertisement is published in the interest of all wire rope users, to help them obtain greater safety, service and efficiency from their wire rope.

ROEBLING
Wire Rope

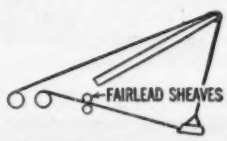
SOME OTHER "REEVING POINTERS" THAT INCREASE ROPE LIFE



These simple changes doubled rope life!

Originally, a 6-inch roller was used, as indicated above, in reeving a hoist. First of all, this roller was too small—causing a sharp bend in the wire rope. Secondly, it was improperly aligned—causing scrubbing action of the rope on the drum. As a result wire rope life suffered.

By simply replacing the 6-inch roller with a 15-inch sheave, and properly aligning this sheave, as shown, excessive rope wear was eliminated. Wire rope life was doubled!



Dragline sheaves replaced —rope life tripled!

An Illinois coal company replaced worn Fairlead sheaves with larger sheaves of harder material. Result—average service of five ropes almost tripled that of five ropes used before.

Ask about ROEBLING "BLUE CENTER" WIRE ROPE . . . *either standard or preformed*

(Reprinted from Bulletin No. 416, American Railway Engineering Association, March 14, 1940). Distributed by The Asphalt Institute, New York.

PORT OF CLEVELAND, OHIO, Lake Series No. 5 (revised 1939)—Prepared By Board of Engineers for Rivers and Harbors, War Department. For sale by Government Printing Office. Washington. Price 70c.

REPORT ON PROGRESS OF THE WPA PROGRAM—June 30, 1939. Issued by Federal Works Agency, Works Projects Administration, Washington.

ALUMINUM RESEARCH LABORATORIES—A description of the new laboratories of the Aluminum Company of America, Pittsburgh, Pa.

LEONARDO DA VINCI E IL REGIME DELLA SPIAGGIA DI CESENATICO—Ricerche Sulle Origini dei Porticanali nel Rinascimento. Published by Stabilimento Tipografico del Genio Civile, Rome.

DEFICIENCIES IN HYDROLOGIC RESEARCH 1940—Report of the Special Advisory Committee on Hydrologic Data, National Resources Planning Board. For sale by Superintendent of Documents, Washington. Price 25c.

THE DESIGN OF PROPELLER PUMPS AND FANS—By Morrough P. O'Brien and Richard G. Folsom. Published by University of California Press, Berkeley, Cal. Price 50c.

A DIGEST OF STATE LAWS Relating to the Problem of Interstate Trade Barriers for States Whose Legislatures Convene in 1940—Prepared by the Marketing Laws Survey, WPA, at the request of the U.S. Department of Commerce and the Interdepartmental Committee on Interstate Trade Barriers.

WILMINGTON, Delaware—Annual Report and Statement, June 30, 1939.

LYNCHBURG, Virginia—Annual Report for year ending 1939.

PASADENA, Calif.—26th Annual Report of Water Dept., 1938-39.

NOVA SCOTIA—20th Annual Report of The Nova Scotia Power Commission, Halifax, N. S.

HAWAII—Report to the Governor by the Superintendent of Public Works, 1939, Honolulu.

METROPOLITAN DISTRICT, Mass.—Annual Report of the Water Supply Commission, Boston, 1938.

PORT OF NEW YORK AUTHORITY—19th Annual Report, 1939.

HENNEPIN COUNTY (Minneapolis), Minn.—Financial Statement, 1939.

CAMBRIDGE, MASS., Annual Report of the City Engineer (for year ending Dec. 31, 1938).

They Like 'em for Hangars Too!

From Maine to California engineers are turning to timber trusses for hangars of all sizes. Here we illustrate a 150' clear span timber truss at Wilmington, Delaware. Top chords are glued solid curved pieces and TECO SPLIT RINGS are used in the lower chord. Note entire truss as a unit is being swung into position.

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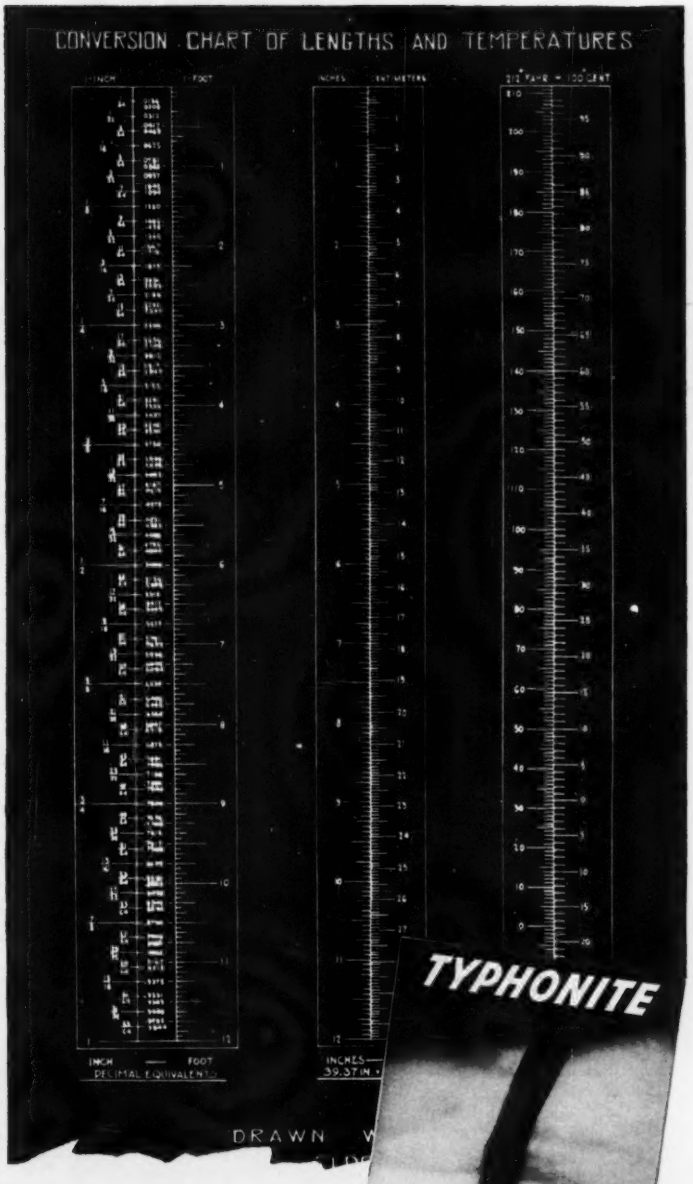

Here's a portion of a complete chart designed to save you time. With it, engineers, designers and draftsmen can quickly and easily convert: 1. Fractional parts of the inch and foot to decimal equivalents; 2. Lengths from inches to centimeters; 3. Temperatures from Fahrenheit to Centigrade.

And just as this chart, drawn with a Typhonite Eldorado, can save you time, so can the pencil itself. Smooth-working leads that stand the gaff help speed work and do it better, too. A test will prove it—prove, too, that Eldorado lines are so opaque that perfect blueprints can be made directly from the original pencil drawing.

FREE—A blueprint of the *complete* conversion chart, made directly from the original Typhonite Eldorado drawing. To get this handy reference chart just write to Pencil Sales Department, JOSEPH DIXON CRUCIBLE COMPANY, Jersey City, N. J. Ask for blueprint No. 227-J5. (Offer good for 30 days from appearance of this ad.)

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PENCIL SALES DEPARTMENT, JOSEPH DIXON CRUCIBLE CO., JERSEY CITY, N. J.

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

HATCHERY BUILDING
WASHINGTON

OWNER: U. S. Bureau of Reclamation, Columbia Basin Project, Washington; J. H. Miner, engineer.

PROJECT: Constructing hatchery building at the Winthrop station for migratory-fish control, Columbia Basin project, about one mile west of Winthrop, Wash. Building will be approximately 45 by 176 ft., with garage wing 36 by 39 ft. Foundations and walls of reinforced concrete. Ground floor of concrete reinforced with wire fabric and placed on compacted fill. Roof trusses, framing and columns of structural steel. Necessary roofing, ventilators, partitions, heating and plumbing and other items for complete structure are also to be provided.

CONDITIONS: Work to be completed in 150 calendar days. Government to furnish cement, reinforcing bars and fabric, plastic joint compound, and structural steel. Access to work from existing roads to be provided by contractor. Sand and gravel deposits suitable for use near work. Wage rates are: skilled labor, $1.00 to $1.65 per hr.; semi-skilled, 85c. to $1.00; and common, 75 to 80c. per hr.

BIDS: Five bids were received April 29, 1940, ranging from the contract low of $44,357 to $52,425.

LOW BIDDERS:

1. C. F. Davidson Co., Tacoma, Wash. (contract) . $44,357
2. John Johnson, Bellingham, Wash. 46,708
3. West Coast Constr. Co., Seattle, Wash. 48,661

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Excavation	1,500 c. y.	$0.70	$0.80	$0.85
2. Backfill	850 c. y.	.70	.75	.50
3. Compacted fills	700 c. y.	2.00	2.00	1.25
4. Conc. in floors, fndn. walls, footings, septic tank	350 c. y.	10.00	8.00	11.50
5. Place reinf. bars and fabric	46,000 lb.	.015	.021	.02
6. Erect str. steel framing for hatchery bldg.	86,000 lb.	.03	.014	.02
7. Constr. hatchery bldg., complete except above items	L.S.	34,542.00	38,500.00	39,421.00

BLACKWATER DAM,
NEW HAMPSHIRE

OWNER: U. S. Engineer Office, Boston, Mass.; Major Leonard B. Gallagher, district engineer.

PROJECT: Construction of Blackwater Dam on Blackwater River near Swett's Mills, N. H., in connection with Merrimac Valley Flood Control. Project includes rolled-earth fill dam with concrete spillway, and connecting concrete non-overflow section. Two rolled-earth dikes, penstock intake structures, spillway and outlet works, gates, hoists and conduit liners also included. Dam embankment about 750 ft. long of pervious material with impervious core. Spillway of concrete gravity Ogee section 240 ft. long. Outlet works consist of four rectangular conduits through spillway. Penstock intake for 16-ft. penstock adjacent to right end of spillway. Non-overflow section connects penstock intake and dam embankment. Dodge Estate dike about 420 ft. long, top width 15 ft., height 18 ft.; Little Hill Dike about 1230 ft. long with top width 22 ft., height approximately 30 ft.

CONDITIONS: Rail and highway transportation facilities available, and project to be completed in 500 calendar days. Conduit liners, gate bonnets and covers, gates, hydraulic hoists and gate hangers to be furnished by government. Wages are: skilled, 75c to $1.50 per hr.; semi-skilled, 50c to 75c.; and common, 45c. per hr.

BIDS: Thirteen bids were opened April 9, 1940, ranging from the contract low of $471,313 to $892,994.

LOW BIDDERS:

1. A. S. Wikstrom, Bound Brook, N. J. (contract) $471,313
2. Carlo Bianchi & Co., Inc., Framingham, Mass. 511,411
3. J. F. Fitzgerald Constr. Co., Boston, Mass. . . . 523,994

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Remove existing structures	L.S.	$100.00	$2,500.00	$1,000.00
2. Diversion, care of river	L.S.	15,000.00	10,000.00	8,950.00
3. Strip dam and dike sites	41,900 c. y.	.50	.40	.45
4. Common excavation	22,200 c. y.	.50	.40	.45
5. Rock excavation	20,550 c. y.	2.50	2.50	1.50
6. Line drilling	6,800 s. f.	.75	1.00	1.00
7. Excav., haul, borrow, area A	43,800 c. y.	.25	.30	.50
8. Excav., haul, borrow, area B	115,800 c. y.	.35	.30	.26
9. Excav., haul, borrow, area D	6,300 c. y.	.25	.40	.22
10. Excav., haul, borrow, area H-1	59,700 c. y.	.23	.30	.48
11. Drill holes, 20 and 30 ft., rock	5,200 l. f.	.50	.75	2.00
12. Drill holes, 40 ft., rock	3,300 l. f.	.55	1.00	2.50
13. Drill holes, rock, grout. anchors	290 l. f.	.85	1.00	1.00
14. Pressure grouting	5,000 c. f.	.70	.50	1.00
15. Rolled fill, impervious	80,200 c. y.	.10	.10	.13
16. Rolled fill, pervious	97,900 c. y.	.10	.20	.13
17. Additional rolling	50,000 sq.	.02	.05	.04
18. Uncompacted backfill	3,900 c. y.	.03	.10	.20
19. Compacted backfill	6,300 c. y.	.30	.50	.60
20. Dumped rock fill, dam embank.	53,500 c. y.	.25	.25	.50
21. Hand-placed riprap, dam site	140 c. y.	2.75	4.00	2.75
22. Gravel, dam embankment	650 c. y.	2.50	1.00	1.00
23. Sand and grav., dam and Dodge Estate dike	14,700 c. y.	.50	1.00	.44
24. Seeded topsoil	4 ac.	500.00	1,050.00	400.00
25. Dumped rock fill, Little Hill dike	8,000 c. y.	125.00	2.00	.60
26. Hand-placed riprap, Little Hill dike	460 c. y.	2.75	4.00	3.00
27. Gravel, Little Hill dike	500 c. y.	2.50	1.00	1.10
28. Sand and grav. Little Hill dike	11,400 c. y.	.25	.75	.44
29. Reinforcing steel	152,200 lb.	.04	.05	.04
30. Furnishing cement	26,300 bbl.	2.80	2.55	2.60
31. Copper water stops	1,250 lb.	.50	.50	.50
32. 8-in. gravel drains	190 l. f.	.35	2.00	.60
33. Concrete in penstock intake	3,150 c. y.	10.00	10.00	8.40
34. Conc. non-overflow, spillway sect.	16,900 c. y.	4.85	5.50	7.05
35. Conc., walls and grout cap	2,400 c. y.	7.00	7.00	7.45
36. Miscellaneous concrete	50 c. y.	10.00	40.00	20.00
37. Tile gages	L.S.	900.00	600.00	300.00
38. Trash bars	23,800 lb.	.13	.12	.14
39. Sheet metal	7,100 lb.	.16	.15	.20
40. Miscellaneous metal	23,900 lb.	.11	.10	.12
41. Hand rail	L.S.	1,000.00	1,500.00	1,250.00
42. Equip. room and stairwell shelter	L.S.	3,000.00	4,000.00	4,400.00
43. Inst. equip. furn. by government	133,000 lb.	.01	.02	.03
44. Gas-elect. generator set, oil press. sys., and misc. equip.	L.S.	2,500.00	3,500.00	3,200.00
45. Electr. power and lighting sys.	L.S.	4,000.00	3,500.00	3,000.00
46. Driveway	L.S.	400.00	1,000.00	300.00
47. Creosoted timber	5.2 M.b.m.	125.00	150.00	100.00

WIDENING PAVEMENT
INDIANA

OWNER: Indiana State Highway Com., T. A. Dicus, chmn.

PROJECT: Widening pavements in Seymour Highway District, Clark County, Ind. Includes 23,000 sq.yd. concrete base (widening), and 900 sq.yd. pavement removal.

CONDITIONS: All materials to be furnished by contractor and project must be completed by Sept. 1, 1940. Highway transportation facilities available. Wage rates: skilled, 75c. per hr.; semi-skilled, 60c.; and common, 50c. per hr.

BIDS: Five bids were opened April 2, 1940, ranging from the contract low of $65,070 to $71,050.

LOW BIDDERS:

1. Ralph Rogers Co., Bloomington, Ind. $65,070
2. Breslin Constr. Co., Louisville, Ky. 65,842
3. McMahan Constr. Co., Rochester, Ind. 67,370

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Portland cement concrete (widening)	23,000 s. y.	$2.79	$2.84	$2.89
2. Pavement removal	900 s. y.	1.00	.58	1.00